

Engineering Design File

Soil Contamination Groundwater Pathway Risk Assessment for CPP-603 EE/CA



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5. Summary: <p>This EDF documents a screening level evaluation of soil contamination in the vicinity of the CPP-603A basins. It includes a description of the soil contamination inventory and a screening level evaluation of the potential risk to the groundwater.</p> <p>Based on this screening level risk assessment, contaminated soil in the vicinity of the CPP-603A facility will not contribute to a cumulative risk from the CPP-603A facility. For groundwater, the performance criteria is to limit migration of contaminants such that based on ingestion of well water in year 2095 and beyond from the Snake River Plain aquifer downgradient of the INTEC security fence (1) the predicted cumulative carcinogenic risk is less than 1×10^{-4}, (2) the predicted total hazard quotient is less than one, and (3) the predicted aquifer concentrations are less than or equal to the Idaho Department of Environmental Quality standards.</p>				
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ACRONYMS

AACC	acceptable ambient concentrations for carcinogens
ARAR	applicable or relevant and appropriate requirement
ASC	allowable soil contamination
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	contaminant of potential concern
CPP	Chemical Processing Plant
DOE	U.S. Department of Energy
EA	environmental assessment
EDF	engineering design file
EPA	U.S. Environmental Protection Agency
FRSF	Fuel Receiving and Storage Facility
ICDF	INEEL CERCLA Disposal Facility
IDAPA	Idaho Administrative Procedures Act
IFSF	Irradiated Fuel Storage Facility
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MCL	maximum contaminant level
MEI	maximally exposed individual
NA	not available
NCRP	National Council on Radiation Protection
NE-ID	U.S. Department of Energy Idaho Operations Office
NEPA	National Environmental Policy Act
O&M	operations and maintenance
OU	operable unit

PEWE	Process Equipment Waste Evaporator
RCRA	Resource Conservation and Recovery Act
RI/BRA	remedial investigation/baseline risk assessment
SF	slope factor
SHADO	small high-activity debris object
USC	United States Code

Soil Contamination Groundwater Pathway Risk Assessment for CPP-603 EE/CA

1. INTRODUCTION

Building CPP-603 in the southern part of INTEC will be deactivated and decontaminated. An engineering evaluation/cost analysis is needed in order to start the deactivation and decontamination. Of interest is an evaluation of the potential for contaminated soil in the vicinity of CPP-603A to significantly contribute to the predicted risk at the CPP-603A facility. This EDF documents a screening level evaluation of the soil (Track 2 Guidance Document, DOE 1994) contamination. It includes a description of the soil inventory and a screening level evaluation of the potential risk to the groundwater.

2. SITE DESCRIPTION AND INVENTORY

There are a number of soil contamination sites in the vicinity of the CPP-603A. This Section presents information from the OU 3-13 Record of Decision (ROD), Section 5.3.3 (DOE-ID 1999) together with updated estimates of the soil contamination volume to generate a soil contamination inventory estimate. Appendix A contains the site information taken for the OU 3-13 ROD. The nuclide inventory is from the Idaho CERCLA Disposal Facility (ICDF) design inventory report (EDF-ER-264).

The “Other Surface Soils” group presented in the OU 3-13 ROD consists of release sites located in areas near Building CPP-603 (Sites CPP-01, -03 -04, -05, -08, -09, -10, -11, and -19). The areas and soil volumes of each of these sites have been estimated and are presented in Table 2-1. The locations of the sites relative to CPP-603 are shown in Figure 2-1. The inventory is discussed in Sections 2-1 and 2-2.

2.1 Estimated Soil Chemical Inventory

As shown in Appendix A, Tables A-5 and A-7, the results of the chemical analyses indicate that chemicals (i.e., nonradionuclides) are basically at background concentration levels in the soil sites of interest. Therefore, no inventory is calculated and no analysis presented for chemicals in this report.

2.2 Estimated Soil Nuclide Inventory

The nuclide soil inventory was taken from the ICDF Design Inventory (EDF-ER-264) and is presented in Table 2-2. The nuclides considered were chosen to be the same nuclides as evaluated in the CPP-603A evaluation. Note that the ICDF has been constructed and at least a portion of the soil from these sites will be excavated and moved to the ICDF. Therefore, using the inventories from the ICDF design inventory report should be a conservative evaluation of the potential risk from the contaminated soil.

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Table 2-1. OU 3-13, Group 3, Other Surface Soil.^a

EC Site	Description	Discussion	Location	Depth of Contamination	Area	Soil Volume
CPP-01 Concrete settling basins and dry wells east of CPP-603	Fuel storage basin cleanup support system. Concrete horizontal settling basin, CPP-740, 4 x 5.3 x 30 ft, basin vol 636 ft ³	Received backwash slurry of filter aid material(diatomaceous earth) from Fuel Receiving and Storage Fac. Filter system.	N. of Bd. 603, E. of a road unk	Ground surface to 32 ft bgs.	Total 4,200 ft ³	
	Concrete vertical settling pit, CPP-301, 5 x 5 x 19 ft, vertical pit volume 475 ft ³		CPP-603	about 30 ft bgs	21 ft ²	
	Dry well, MAH-SFE-SW-048		E. of Bd. CPP-603	about 19 ft bgs	25 ft ²	
	Dry well, MAH-SFE-SW-303		E. end of CPP-740	Bottom of Dry Well is about 20 ft bgs	?	
			E. of the S.E. corner of Bld. 603	Bottom of Dry Well is about 20 ft bgs	?	
CPP-03	Former temporary storage area southeast of CPP-603	Temporary storage area for radioactively contaminated equipment. Decommissioned/ contaminated soil was replaced w "cold". Next Tank Farm soil was stock piled here prior to burial. Tank Farm soil has been removed. 150 ft x 500 ft	S.E. of CPP-603	Upper few feet (GS to 4 ft bgs)	75,000 ft ²	300,000 ft ³
CPP-04 Contaminated soil area above CPP-740 settling basin	Contaminated unintentional during sludge removal 33 x 67 ft	Unintentional contamination during sludge removal 33 x 67 ft	E. of CPP-603	Upper few feet (ave. 2 ft bgs)	2,211 ft ²	4,422 ft ³
CPP-05 Contaminated soil above CPP-301 setting pit			E. of CPP-603	Upper few feet (ave. 2 ft bgs)	2,211 ft ²	4,422 ft ³
CPP-08 CPP-603 basin filter system line failure	Failure of an underground carbon steel filter – 45 ft x 60 ft (appear to be under 603)		E. of CPP-603	Depth of contamination at 31 ft bgs.	1,350 ft ²	41,850 ft ³
CPP-09 Soil contamination at northeast corner of CPP-603 south basin	Failure of an underground carbon steel filter – corrosion 60 ft x 45 ft (appear to be under 603)	E. of CPP-603	Depth of contamination at 31 ft bgs.	1,350 ft ²	41,850 ft ³	
CPP-10 CPP-603 plastic pipeline break	Basin water contaminated asphalt and soil/clean soil used to cover this. 24 ft x 14 ft	E. of CPP-603	GS to 34 ft bgs	336 ft ²	11,424 ft ³	
CPP-11 CPP-603 sludge and water release	Site lies directly above the SFE-106 (or -06) liquid waste tank, which is frequently sampled. Surface soils are contaminated with ongoing tank sampling efforts. Above background samples collected at 12.5 ft bgs. About 28 ft x 56 ft = 1,568 ft ² (May be partially under CPP-648)	E. of CPP-603	GS to 18 ft bgs	2,240 ft ²	40,390 ft ³	
CPP-19 CPP-603 to CPP-604 line leak	Waste line at 5 ft bgs, contamination to 31 ft bgs, 408,000 pCi/g Cs-237 (possible piping contamination issue)	CPP-603	GS to soil/basalt level or about 31 ft	4,000 ft ²	124,000 ft ³	

a. This table was provided by Jodi Bragassa, BBWI and is considered to be the best estimates currently available for the contaminated soil areas and volumes.

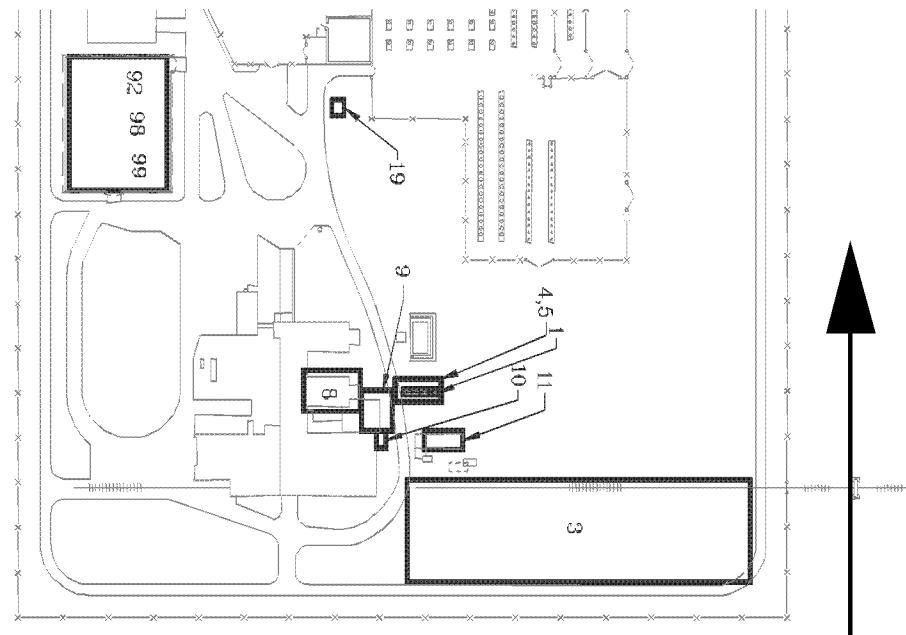


Figure 2-1. Contaminated soil sites including those near CPP-603.

3. NUCLEIDE SCREENING

A number of the nuclides identified in the inventory are relatively short lived and have no long-lived progeny. The vadose zone is very deep and the water travel time from the surface soil to the groundwater (based on the Section 4 assumptions) is about 78 years assuming no dispersion in the unsaturated zone. Retardation in the vadose zone increases the time to the aquifer based on the soil to water partitioning coefficient. Since many of the nuclides in the inventory are relatively short-lived nuclides, these nuclides cannot reach the aquifer because they will decay away during transport through the vadose zone. Table 3-1 shows the nuclides evaluated in the CPP-603A streamlined risk assessment (EDF-4488), the estimated travel times to the aquifer, and the number of radioactive half lives the nuclide will go through during vadose zone transport. After 10 half lives approximately 0.1% (or 1/1000th) of the nuclide is remaining and after 20 half lives approximately 0.0001% (or 1/1,000,000th) of the nuclide is remaining. The parameters used for the calculation shown in Table 3-1 are:

- | | | |
|---|---|----------------------------|
| • Infiltration rate (I) | = | 0.1 m/y |
| • Unsaturated moisture content (θ) | = | 0.345 |
| • Vadose zone thickness (T) | = | 22.7 m |
| • Unsaturated pore velocity ($v=I/\theta$) | = | 0.29 m/y |
| • Vadose zone travel time for water (T/v) | = | 78.2 y |
| • Soil bulk density (ρ) | = | 1.36 g/mL |
| • Retardation (R) | = | $1 + (\rho * Kd / \theta)$ |

As can be seen in Table 3-2, the nuclides that do not screen out are nuclides with relatively small Kd values or very long radioactive decay half lives. The nuclides from Table 3-1 that do not screen are C-14, H-3, I-129, Np-237, Pu-238, Pu-239, Pu-240, Tc-99, U-234, U-235, U-236 and U-237. In addition, Am-241 and Pu-238 are added as a contaminant of concern because they decay to Np-237 and U-234, respectively and Np-237 and U-234 are contaminants of concern. In the simulations, Am-241 is treated as Np-237 and Pu-238 is treated as U-234. Therefore, the list of contaminants of concern includes all of the contaminants of concern identified for the CPP-603A evaluation (EDF-4488) plus H-3 and U-236.

Table 3-1. Soil sites total inventory in activity.

Nuclide	CPP-01/04/05 (Ci)	CPP-03 (Ci)	CPP-08/09 (Ci)	CPP-10 (Ci)	CPP-11 (Ci)	CPP-19 (Ci)	Total (Ci)
Am-241	1.09E-02	7.66E-05	6.46E-04	9.69E-05	1.49E-05	8.52E-03	2.03E-02
C-14	1.92E-07	8.37E-10	7.06E-09	1.06E-09	1.63E-10	1.49E-06	1.69E-06
Cm-244	7.52E-06	3.28E-08	2.76E-07	4.14E-08	6.36E-09	5.83E-05	6.61E-05
Co-58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	1.01E+01	0.00E+00	0.00E+00	1.33E-03	4.39E-04	8.08E+01	9.09E+01
Cs-137	1.02E+02	4.44E-01	3.74E+00	5.61E-01	8.62E-02	7.89E+02	8.96E+02
Eu-152	9.96E+01	1.69E-02	1.47E-02	4.19E-03	4.64E-07	3.59E+02	4.58E+02
Eu-154	1.57E+02	1.11E-03	9.60E-03	2.53E-03	1.83E-03	2.12E+02	3.69E+02
Eu-155	3.17E+01	6.72E-04	5.67E-03	6.15E-04	1.31E-04	3.57E+01	6.74E+01
H-3	2.06E-01	8.99E-04	7.58E-03	1.14E-03	1.75E-04	1.60E+00	1.82E+00
I-129	3.86E-05	1.68E-07	1.42E-06	2.13E-07	3.26E-08	2.99E-04	3.39E-04
Nb-95	2.00E-35	8.72E-38	7.36E-37	1.10E-37	1.69E-38	1.55E-34	1.76E-34
Np-237	1.82E-04	7.91E-07	6.67E-06	1.00E-06	2.56E-04	1.41E-03	1.85E-03
Pu-238	4.99E-02	2.17E-04	1.83E-03	2.75E-04	4.22E-05	3.86E-01	4.39E-01
Pu-239	2.78E-02	1.21E-04	1.02E-03	1.53E-04	2.35E-05	2.15E-01	2.44E-01
Pu-240	6.25E-03	2.72E-05	2.30E-04	3.45E-05	5.29E-06	4.85E-02	5.50E-02
Sr-90	9.54E+01	4.15E-01	3.50E+00	5.26E-01	8.07E-02	7.39E+02	8.39E+02
Tc-99	2.40E-02	1.05E-04	8.82E-04	1.32E-04	2.03E-05	1.86E-01	2.11E-01
Th-228	2.31E-06	1.00E-08	8.47E-08	1.27E-08	1.95E-09	1.79E-05	2.03E-05
U-234	2.51E-02	1.09E-04	9.24E-04	1.38E-04	2.13E-05	1.95E-01	2.21E-01
U-235	1.03E-03	2.92E-06	9.24E-05	6.78E-06	5.67E-07	1.02E-02	1.14E-02
U-236	8.43E-04	3.67E-06	3.10E-05	4.64E-06	7.13E-07	6.53E-03	7.41E-03
U-238	1.10E-03	3.11E-08	5.72E-04	1.02E-04	1.71E-03	1.96E-03	5.45E-03
Zr-95	9.05E-36	3.94E-38	3.33E-37	4.99E-38	7.66E-39	7.01E-35	7.96E-35

Table 3-2. Screening based on radioactive decay half-life and estimated travel time to the aquifer.

Nuclide	Half-Life (years)	Kd Soil (ml/g)	Retardation	Estimated Aquifer Travel Time (years)	Number Half Lives
Am-241	4.32E+02	340	1342	104,966	243
C-14	5.73E+03	0.1	1	109	0
Cm-244	1.81E+01	500	1973	154,325	8526
Co-58	1.94E-01	10	40	3,163	16305
Co-60	5.27E+00	10	40	3,163	600
Cs-137	3.02E+01	500	1973	154,325	5110
Eu-152	1.36E+01	340	1342	104,966	7718
Eu-154	8.80E+00	340	1342	104,966	11928
Eu-155	4.96E+00	340	1342	104,966	21162
H-3	1.23E+01	0	1	78	6
I-129	1.57E+07	0.1	1	109	0
Nb-95	9.58E-02	100	395	30,928	322834
Np-237	2.14E+06	8	33	2,546	0
Pu-238	8.77E+01	140	553	43,267	493
Pu-239	2.41E+04	140	553	43,267	2
Pu-240	6.56E+03	140	553	43,267	7
Sr-90	2.91E+01	12	48	3,780	130
Tc-99	2.13E+05	0.2	2	140	0
Th-228	1.91E+00	100	395	30,928	16192
U-234	2.45E+05	6	25	1,929	0
U-235	7.04E+08	6	25	1,929	0
U-236	2.34E+07	6	25	1,929	0
U-238	4.47E+09	6	25	1,929	0
Zr-95	1.75E-01	600	2368	185.174	1058137

4. MODELING APPROACH AND ASSUMPTIONS

The basic conceptual model and associated parameters chosen for the transport model for the soil contamination are consistent with the ICDF-CA model (DOE-ID 2002) and the CPP-603 EE/CA model (EDF-4488). A unit mass or activity of each contaminant is used to calculate the resulting concentration at a receptor location. This concentration is then compared with a limiting concentration calculated based on a cancer risk of 10^{-4} or 10^{-6} . Using this information, an allowable soil contamination (ASC) inventory for each contaminant is calculated and compared with the projected inventory in the contaminated soil.

4.1 Source Area and Volume

The soil sites are shown in Figure 2-1 and the individual dimensions are summarized in Table 2-1. The soil sites are distributed over an area of about 200 m x 200 m. The sites vary significantly in their size and total estimated inventory. Contaminants will be leached from the soil and spread in the vadose zone before entering the aquifer and potentially mixing with contaminants from other sites, such as the CPP-603A facility. The extent of mixing in the vadose zone is not well characterized, but it is reasonable to expect that the contaminants will not spread sufficiently to cover the entire 200 m x 200 m area. For purposes of this evaluation, it is assumed that the inventories from all the sites are accumulated into one square area. The dimensions of the area are chosen to be 100 m x 100 m because that is generally the smallest scale used at the INEEL for aquifer flow and transport analysis. The thickness of the contaminated soil area is chosen to be 9.5 m (31 ft) because soil site CPP-19 contributes the majority of the inventory and 9.5 m is the estimated thickness of the contaminated soil at CPP-19.

4.2 Flow and Transport Assumptions Summary

The following flow and transport related assumptions were made for the analysis:

- The groundwater pathway is assumed to be the only significant contaminant exposure pathway.
- This evaluation assumes that the current estimated inventory in contaminated soil would be left in place. This is conservative because there are plans to excavate and move some (if not all) of the soil to the ICDF.
- Water and contaminants move straight down through the vadose zone sediments. The contaminant velocity through the sediments depends on the contaminant specific sediment Kd. There is no retardation effect from the basalt and there is no horizontal spreading in the vadose zone. Based on the results of the calibration to the remedial investigation/baseline risk assessment (RI/BRA) model (DOE-ID 1997), the absence of lateral spreading is a conservative assumption.
- The contaminant solubility is conservatively assumed to be infinite for these analyses. If a contaminant appears to pose a significant risk to the groundwater quality, then a reasonable solubility limit could be identified and incorporated into the analysis in the future.
- ASC inventories for nuclides are calculated based on limiting aquifer concentrations corresponding to a 10^{-4} and 10^{-6} risk.
- The receptor is assumed to be about 100-m downgradient from the edge of the accumulated soil source.

- The ASC inventories are based on a predicted peak aquifer concentration regardless of the time of peak. In some cases, the ASC inventory would be much lower if the timeframe of interest was reduced to 1,000 or 10,000 years.
- The ASC inventory for Am-241 is the activity equivalent of the ASC inventory calculated for the Np-237. This assumption was made because the Am-241 decays relatively quickly to Np-237 and the Am-241 is basically immobile in comparison with Np-237. Therefore this conservative assumption is equivalent to assuming that the Am-241 decays immediately to Np-237.
- The ASC inventory for Pu-238 is the activity equivalent of the ASC inventory calculated for the U-234. This assumption was made because the Pu-238 decays relatively quickly to U-234 and the Pu-238 is basically immobile in comparison with U-234. Therefore this conservative assumption is equivalent to assuming that the Pu-238 decays immediately to U-234.
- The *GWSCREEN: A Semi-Analytical Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination: Version 2.0 Theory and User's Manual* (Rood 1999) is used for the source release and contaminant transport simulations.

4.3 Contaminant Specific Assumptions

Listed below are the major contaminant-specific assumptions:

- The contaminant specific partition coefficient (Kd) values are consistent with those used in the ICDF-CA (DOE-ID 2002) and the CPP-603 EE/CA (DOE/NE-ID 2004, EDF-4488), which are based primarily on Track 2 default values (DOE, 1994), and those used in the ICPP RI/BRA report (DOE-ID, 1997).
- In the ICPP RI/BRA report, it was assumed that the aquifer basalt Kd values are 25 times smaller than the assumed soil Kd values. The same assumption was used in the ICDF-CA, CPP-603 EE/CA and this evaluation.
- Radionuclide progeny were included in the analysis. The progeny are assumed to move with the parent nuclide in the GWSCREEN simulations.

4.4 Conceptual Model

The conceptual model used for the analysis is shown in Figure 4-1. The parameter values used in the GWSCREEN simulations that are not contaminant specific are shown in Table 4-1. The nuclide specific parameter values are shown in Table 4-2.

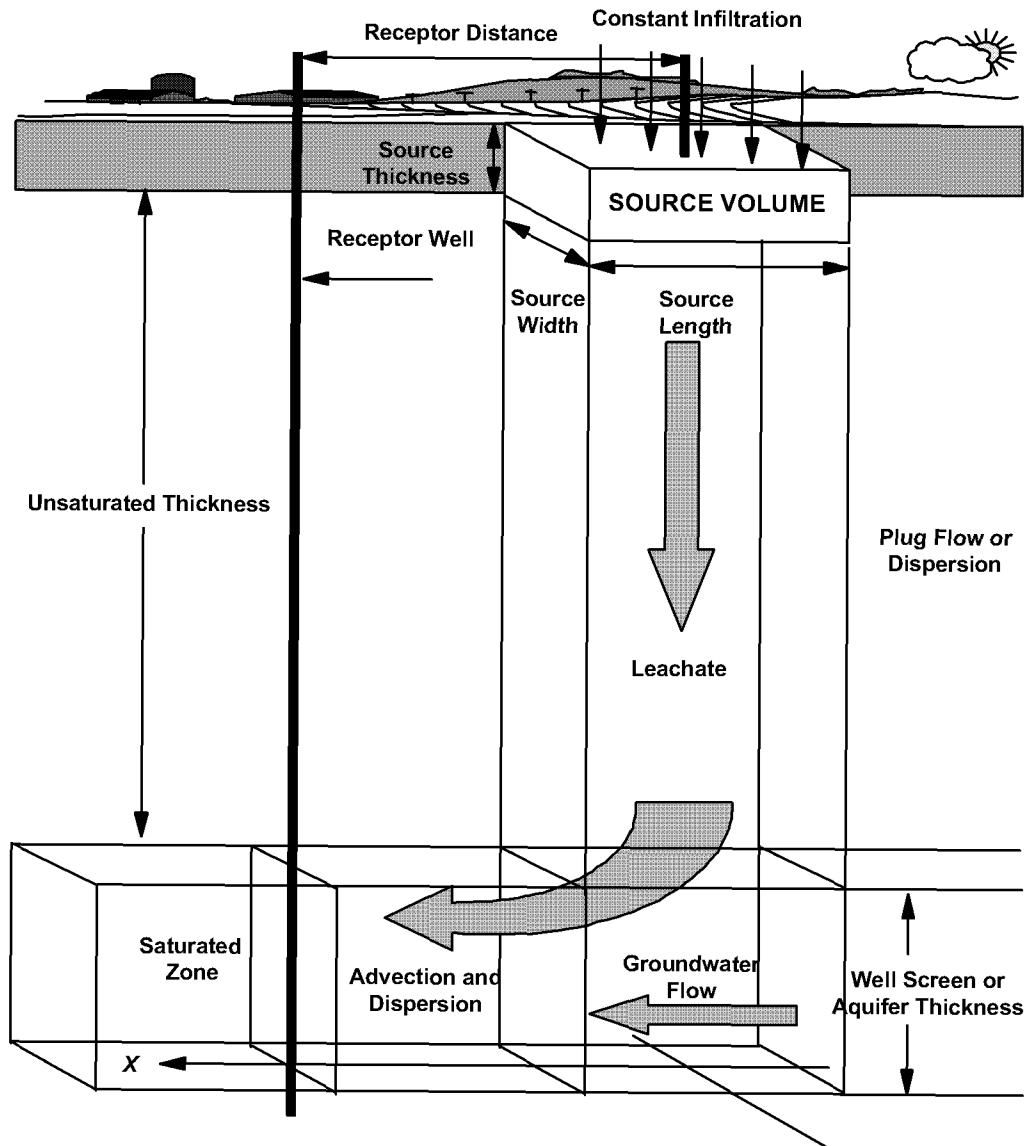


Figure 4-1. Conceptual model of GWSCREEN for the source volume, unsaturated zone, and aquifer (Rood 1999).

Table 4-1. Constant parameter values used in the soil contamination simulations.

Parameter	Values	Source of Parameter Values
Source		
Length	100 m	Section 3.1
Width	100 m	Section 3.1
Thickness	9.5 m	Section 3.1
Bulk Density	1.5 g/cm ³	ICDF-CA (DOE-ID 2003)
Moisture content	0.3	OU 3-13 RI/BRA (DOE-ID 1997)
Infiltration Rate	0.1 m/y	Track 2 Guidance Document (DOE 1994) and OU 3-13 RI/BRA (DOE-ID 1997)
Unsaturated Zone		
Thickness (cumulative interbeds)	22.7 m	ICDF-CA (DOE-ID 2003)
Longitudinal Dispersivity	2.92 m	ICDF-CA (DOE-ID 2003)
Bulk Density	1.36 g/cm ³	ICDF-CA (DOE-ID 2003)
Moisture content ^a	0.345	Calculated in GWSCREEN
Aquifer		
Thickness	76 m	ICDF-CA (DOE-ID 2003)
Well Screen Thickness	15 m	Track 2 Guidance Document (DOE 1994)
Darcy Velocity	21.9 m/y	ICDF-CA (DOE-ID 2003)
Average Linear Velocity	365 m/y	Calculated in GWSCREEN
Porosity	0.06	ICDF-CA (DOE-ID 2003)
Bulk Density	2.49 g/cm ³	ICDF-CA (DOE-ID 2003)
Variable Longitudinal Dispersivity ^b	4.9 m	Calculated in GWSCREEN at 100 m from CPP-603
Ratio Transverse / Longitudinal	0.2	ICDF-CA (DOE-ID 2003)
Ratio Vertical / Longitudinal	0.00116	ICDF-CA (DOE-ID 2003)
Receptor Distance from the Center of the Source		
x (along flow direction)	150 m	100 m downgradient of the edge of the soil source
y (perpendicular to flow direction)	0 m	Along the line of maximum concentration
Receptor Scenario		
Drinking water ingestion rate	2 L/day	
Exposure frequency	350 d/yr	
Exposure duration	30 yr	
Averaging time	70y=25,550d	

a. characteristic curve in the vadose zone uses the van Genuchten formulation to calculate the moisture content (Rood 1999). The parameter values used are;

- residual moisture content = 0.142
- saturated moisture content = 0.487
- saturated hydraulic conductivity (m/y) = 21.13
- a fitting parameter (1/m) = 1.066
- n fitting parameter = 1.523

b. longitudinal dispersivity is defined as $1.20(\log_{10} L)^{2.958}$ where L=121.45m (Rood 1999, Section 2.3)

Table 4-2. Radionuclide contaminant-specific-parameter values used in the GWSCREEN Analysis.

COPCs Parent Progeny	Radioactive Half-Life (yr)	Risk Coefficients ^b (1/pCi)	10^{-6} Risk Based Water Conc ^c (pCi/L)	Inventory Estimate (Ci)	Soil-Water Partition Coef. (Kd) ^a	
					Soil (mL/g)	Aquifer (mL/g)
Am-241 (sim.as Np-237)	432	3.28E-10	1.46E-01	2.03E-02	340	13.6
Np-237 (from Am-241)	2.14E+06	3.00E-10	1.60E-01	4.17E-06	8	0.32
U-233	1.59E+05	4.48E-11	1.07E+00		6	0.24
Th-229	7340	3.56E-10	1.35E-01		100	4
C-14	5.73E+03	1.03E-12	4.62E+01	1.69E-06	0.1	0.004
H-3	12.3	7.2E-14	6.71E+02	1.82E+00	0	0
I-129	1.57E+07	1.84E-10	2.59E-01	3.39E-04	0.1	0.004
Np-237	2.14E+06	3.00E-10	1.60E-01	1.85E-03	8	0.32
U-233	1.59E+05	4.48E-11	1.07E+00		6	0.24
Th-229	7340	3.56E-10	1.35E-01		100	4
Pu-238 (sim.as U-234)	87.8	2.95E-10	1.63E-01	4.39E-01	140	5.6
U-234 (from Pu-238)	2.45E+05	4.44E-11	1.08E+00	1.60E-04	6	0.24
Th-230	7.54E+04	3.75E-11	1.28E+00		100	4
Ra-226	1600	2.96E-10	1.62E-01		100	4
Pb-210	22.3	1.01E-09	4.75E-02		100	4
Pu-239	2.41E+04	3.16E-10	1.52E-01	2.44E-01	140	5.6
U-235	7.04E+08	4.70E-11	1.02E+00		6	0.24
Pa-231	3.28E+04	1.49E-10	3.19E-01		550	22
Ac-227	21.8	6.26E-10	7.60E-02		450	18
Pu-240	6.56E+03	3.15E-10	1.51E-01	5.50E-02	140	5.6
U-236	2.34E+07	4.21E-11	1.13E+00		6	0.24
Th-232	1.41E+10	3.28E-11	1.45E+00		100	4
Ra-228	5.75	2.48E-10	1.92E-01		100	4
Pb-210	1.91	2.31E-10	2.06E-01		100	4
Tc-99	2.11E+05	1.40E-12	3.40E+01	2.11E-01	0.2	0.008
U-234	2.45E+05	4.44E-11	1.08E+00	2.21E-01	6	0.24
Th-230	7.54E+04	3.75E-11	1.28E+00		100	4
Ra-226	1600	2.96E-10	1.62E-01		100	4
Pb-210	22.3	1.01E-09	4.75E-02		100	4
U-235	7.04E+08	4.70E-11	1.02E+00	1.14E-02	6	0.24
Pa-231	3.28E+04	1.49E-10	3.19E-01		550	22
Ac-227	21.8	6.26E-10	7.60E-02		450	18
U-236	2.34E+07	4.21E-11	1.13E+00	7.41E-03	6	0.24
Th-232	1.41E+10	3.28E-11	1.45E+00		100	4
Ra-228	5.75	2.48E-10	1.92E-01		100	4
Pb-210	1.91	2.31E-10	2.06E-01		100	4
U-238	4.47E+09	6.20E-11	7.68E-01	5.45E-03	6	0.24
U-234	2.45E+05	4.44E-11	1.08E+00		6	0.24
Th-230	7.54E+04	3.75E-11	1.28E+00		100	4
Ra-226	1600	2.96E-10	1.62E-01		100	4
Pb-210	22.3	1.01E-09	4.75E-02		100	4

Note – progeny ingrowth was ignored for the first 500 years.

a. From DOE-ID (2003) the ICDF Composite Analysis.

b. Slope factors are taken from the tables in DOE-ID, 1997 in order to be consistent with the OU 3-13 Comprehensive RI/BRA. They are based on FGR-13. The exposure parameters are listed in Table 4-1.

c. The risk-based concentrations are calculated based on the Risk Coefficients and exposure parameters.

5. OU 3-13 SOIL CONSERVATIVE RISK ASSESSMENT RESULTS

The results of this screening level evaluation for the potential nuclides of interest are shown in Table 5-1. The table includes model predictions based on a unit inventory, calculated ASC inventories and a comparison with the estimated total nuclide inventory for the soil sites in the vicinity of CPP-603A. Of the nuclides, U-234 has an estimated inventory that would result in a 2×10^{-6} risk-based concentration in approximately 2,260 years. All other nuclides have estimated inventories that would result in less than a 1×10^{-6} risk-based concentration.

Am-241 and Pu-238 are nuclides that are strongly sorbed but decay relatively quickly to more mobile contaminants (Np-237 and U-234). Therefore, exposure and risk in the aquifer from Am-241 and Pu-238 would come from the progeny Np-237 and U-234, respectively. In Table 5-1, the Am-241 and Pu-238 ASC inventories are the activity equivalent of the ASC inventories calculated for the Np-237 and the U-234, respectively.

Table 5-1. Compare the calculated allowable soil contamination inventory with the estimated inventory.

	10^{-6} Risk Based Water Conc. (pCi/L)	Predicted From Unit Inventory		ASC Inventory ^a		Estimated Soil Inventory (Ci)
		Time of Peak Concentration (Years)	Peak Concentration (pCi/L)	10^{-6} Risk (Ci)	10^{-4} Risk (Ci)	
Am-241 ^b as Np-237 U-233 Th-229	1.46E-01	Am-241 assumed to be all Np-237		1.10E+02	1.10E+04	2.03E-02
	1.60E-01	2.99E+03	7.02E+00	2.26E-02	2.26E+00	4.17E-06
	1.07E+00					
	1.35E-01					
C-14	4.62E+01	1.23E+02	1.71E+02	2.74E-01	2.74E+01	1.69E-06
H-3	6.71E+02	4.72E+01	7.68E+00	9.74E+01	9.74E+03	1.82E+00
I-129 ^d	2.59E-01	1.24E+02	1.73E+02	1.51E-03	1.51E-01	3.39E-04
Np-237 U-233 Th-229	1.60E-01	2.99E+03	7.02E+00	2.26E-02	2.26E+00	1.85E-03
	1.07E+00		1.19E-01			
	1.35E-01		1.00E-03			
Pu-238 ^b U-234 Th-230 Ra-226 Pb-210	1.63E-01	Pu-238 assumed to be all U-234		3.14E+02	3.14E+04	4.39E-01
	1.08E+00	2.26E+03	3.49E+01	1.15E-01	1.15E+01	1.60E-04
	1.28E+00					
	1.62E-01					
	4.75E-02					
Pu-239 U-235 Pa-231 Ac-227	1.52E-01	3.85E+04	1.17E-01	1.29E+00	1.29E+02	2.44E-01
	1.02E+00		1.73E-04			
	3.19E-01		7.56E-07			
	7.60E-02		9.23E-07			
Pu-240 U-236 Th-232 Ra-228 Th-228	1.51E-01	2.60E+04	1.07E-02	1.40E+01	1.40E+03	5.50E-02
	1.13E+00		9.29E-04			
	1.45E+00		5.49E-11			
	1.92E-01		5.48E-11			
	2.06E-01		5.48E-11			
Tc-99	3.40E+01	1.60E+02	1.33E+02	2.57E-01	2.57E+01	2.11E-01
U-234 Th-230 Ra-226 Pb-210	1.08E+00	2.26E+03	9.22E+00	1.15E-01	1.15E+01	2.21E-01
	1.28E+00		1.25E-02			
	1.62E-01		4.54E-03			
	4.75E-02		4.43E-03			
U-235 Pa-231 Ac-227	1.02E+00	2.26E+03	9.28E+00	1.08E-01	1.08E+01	1.14E-02
	3.19E-01		5.20E-03			
	7.60E-02		6.27E-03			
U-236 Th-232 Ra-228 Pb-210	1.13E+00	2.26E+03	9.28E+00	1.22E-01	1.22E+01	7.41E-03
	1.45E+00		6.78E-08			
	1.92E-01		6.75E-08			
	2.06E-01		6.75E-08			
U-238 U-234 Th-230 Ra-226 Pb-210	7.68E-01	2.26E+03	9.28E+00	8.24E-02	8.24E+00	5.45E-03
	1.08E+00		5.93E-02			
	1.28E+00		4.02E-05			
	1.62E-01		1.05E-05			
	4.75E-02		1.01E-05			

a. The ASC inventory is based on the total risk including progeny. The risks for each of the progeny is not shown in this table but is calculated in GWSCREEN and incorporated into the calculation of the ARC inventory.

6. SUMMARY AND DISCUSSION

This EDF documents a screening level evaluation of the soil contamination for soil in the vicinity of the CPP-603A basins. It includes a description of the soil inventory and a screening level evaluation of the potential risk to the groundwater.

The results of the chemical analyses on soil samples indicate that nonradionuclide contaminants are basically at background concentration levels in the soil sites of interest. Therefore, no inventory is calculated and no analysis presented for nonradionuclides in this report. The nuclide soil inventory was taken from the ICDF Design Inventory (EDF-ER-264). The nuclides considered were chosen to be the same nuclides as evaluated in the CPP-603A evaluation.

Based on the vadose zone travel time and the radioactive decay half-life, the list of potential nuclide contaminants of concern were screened. The nuclides that do not screen out are nuclides with relatively small Kd values or very long radioactive decay half-lives. The nuclide contaminants of concern are C-14, H-3, I-129, Np-237, Pu-238, Pu-239, Pu-240, Tc-99, U-234, U-235, U-236 and U-238. In addition, Am-241 and Pu-238 screened out but were included as contaminants of concern because they decay to Np-237 and U-234, respectively and Np-237 and U-234 are contaminants of concern. The list of contaminants of concern includes all of the contaminants of concern identified for the CPP-603A evaluation (EDF-4488) plus H-3 and U-236.

The results of this screening level evaluation indicate that U-234 has an estimated inventory that would result in a 2×10^{-6} risk based concentration in approximately 2,260 years. All other nuclides have estimated inventories that would result in less than a 1×10^{-6} risk based concentration.

The screening analysis was based on a number of conservative assumptions. The following summarizes the key conservative assumptions:

- Assumed infiltration rate is 10 cm/y, or 10 times the natural infiltration rate for undisturbed soils at the INEEL (or a simple soil cover) and more conservative if an infiltration reducing cover were constructed. The implementation of a soil or engineered barrier over the contaminated soil will further decrease the impact of the contaminated soil on the groundwater risk.
- Inventories from all the sites are accumulated into one square area with dimensions of 100 m × 100 m rather than distributed over the entire area of the soil sites.
- This evaluation assumes that the current estimated inventory in contaminated soil would be left in place. This is conservative because there are plans to excavate and move some (if not all) of the soil to the ICDF. Any remediation of the soil will further decrease the impact of the contaminated soil on the groundwater risk.
- In the vadose zone there is no retardation effect from the basalt and no horizontal spreading.

Based on this screening level risk assessment, contaminated soil in the vicinity of the CPP-603A facility will not contribute to a cumulative risk from the CPP-603A facility. For groundwater, the performance criteria is to limit migration of contaminants such that based on ingestion of well water in year 2095 and beyond from the Snake River Plain aquifer downgradient of the INTEC security fence (1) the predicted cumulative carcinogenic risk is less than 1×10^{-4} , (2) the predicted total hazard quotient is less than one, and (3) the predicted aquifer concentrations are less than or equal to the Idaho Department of Environmental Quality standards.

7. REFERENCES

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Appendix A

OU 3-13 Soil Data Tables and Description from the OU 3-13 ROD

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Appendix A

OU 3-13 Soil Data Tables and Description from the OU 3-13 ROD

The following is taken directly from Section 5.3.3 of the OU 3-13 ROD (DOE-ID 1999).

CPP-01 (Concrete Settling Basins and Dry Wells East of CPP-603). This site is associated with the fuel storage basin cleanup support system, and consists of the concrete horizontal settling basin (CPP-740), concrete vertical settling pit (CPP-301), and two dry wells (CPP-303 and MAH-SFE-SW-048) east of CPP-603. The fuel storage basin cleanup support system received a backwash slurry of filter aid material (diatomaceous earth) from the Fuel Receiving and Storage Facility filter system. The shielding water in the fuel storage basin was recirculated through the filters to prevent accumulation of dirt and algae. The filtered solids and filter aid material were periodically backwashed from the filters and pumped to CPP-301, a $1.5 \times 1.5 \times 5.8$ m ($5 \times 5 \times 19$ ft) vertical settling vault. When the slurry in the vault settled, the supernatant was drained from the vault to a deep dry well, CPP-303, where the effluent percolated into the surrounding soils.

The filter backwash settling system operated from 1951 to 1962. The horizontal settling system was constructed in 1962. The system consisted of a horizontal settling basin CPP-740 and dry well SW-048. The CPP-301 was removed from service and valved off. The CPP-740 basin included a $1.2 \times 1.6 \times 9.1$ m ($4 \times 5.3 \times 30$ ft) horizontal settling system of weir compartments and an access manhole. This system served to settle slurry solids and to drain the supernatant to dry well SW-048 and subsequently the surrounding soils. The total volume (18,295 L [5,000 gal]) of sludge and liquid in the horizontal settling basin CPP-740 and the vertical settling pit CPP-301 was removed in the fall of 1993 under a CERCLA removal action. The liquid removed was sent to the PEW facility and the sludge was dried and sent to the RWMC.

Use of dry wells was discontinued in 1966 due to internal administrative controls. This decision prompted reactivation of CPP-301 as a settling pit. Upon reactivation, steam jetting was used to transfer the supernatant to waste storage tank SFE-20 (Site CPP-69 in OU 3-09). In March 1969, several Experimental Breeder Reactor (EBR) No. 2 fuel canisters ruptured, releasing contamination to the basin water. The CPP-740 settling facilities were removed from service in 1977 when the filters were replaced by a pressurized sand filtration system.

Depth of contamination at CPP-01 is assumed to extend from ground surface to the sediment/basalt interface at 9.8 m (32 ft) bgs. Table A-1 (OU 3-13 ROD Table 5-7) provides summary sampling results statistics for CPP-01.

CPP-04/05 (Contaminated Soil Area Around CPP-603 Settling Tank). These sites located east of CPP-603 were combined because they were determined to have resulted from the same release. Site CPP-04 includes a 10.0×20.4 m (33×67 ft) area of contaminated soil above the horizontal settling basin CPP-740. Site CPP-05 includes a 10.0×20.4 m (33×67 ft) area of contaminated soil above the vertical settling pit CPP-301. Soil contamination associated with the two sites resulted from unintentional releases during sludge removal from the two structures in 1978.

The contaminated area was later covered with 0.6 m (2 ft) of soil. Table A-2 (OU 3-13 ROD Table 5-8) shows summary sampling results statistics for CPP-04/05.

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Table A-1. (OU 3-13 ROD Table 5-7) Summary sampling results statistics for soil contaminants at Site CPP-01.^a

Contaminants	Soil Concentration (pCi/g [radionuclide])			RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean						
Am-241	1.78E+00	J	1.78E+00	NA	NA	3	1	33%	1.10E-02
Co-57	1.02E+00		1.02E+00	1.02E+00	NA	19	1	5%	NA
Co-60	1.38E+00		3.32E+02	7.12E+01	1.46E+02	3.63E+02	19	5	26%
Cs-137	1.29E+00		4.60E+04	4.64E+03	1.20E+04	2.86E+04	19	15	79%
Eu-152	2.23E+00		1.04E+02	5.37E+01	5.75E+01	1.69E+02	19	4	21%
Eu-154	4E+00		7.97E+01	5.03E+01	4.06E+01	1.32E+02	19	3	16%
Eu-155	8.81E+00		8.81E+00	NA	NA	19	1	5%	NA
Pu-239	5.30E+00	J	1.20E+01	J	8.83E+00	3.36E+00	1.56E+01	11	3
Sr-90	1.11E+01		4.85E+03	9.43E+02	1.46E+03	3.86E+03	16	16	100%
U-235	9.34E-03		3.94E-02	2.40E-02	8.55E-03	4.11E-02	11	11	100%
U-238	1.12E-01		2.50E-01	2.01E-01	4.26E-02	2.86E-01	11	11	100%
Gross Alpha	4.30E+00		3.32E+03	4.47E+02	8.61E+02	2.17E+03	19	14	74%
Gross Beta	7.46E+00		4.32E+04	4.99E+03	1.01E+04	2.52E+04	19	19	100%

a. NOTE:

- Duplicate sample results were not included in the statistical analysis
- Analytical results are from samples collected from three borings and from the bottom of dry well SW-048 during the OU 3-09 Track 2 Investigation. Results are provided in the Final Preliminary Scoping Track 2 Summary Report For Operable Unit OU 3-09 (IITCO 1995b) and Appendix G of the OU3-13 RI/FS Part A (DOE-ID 1997b).
- Selected samples were also analyzed for Cd, K-40, Np-237, Pu-238, and U-234. This data is not shown because concentrations were below detection limits.
- Samples rejected because of an unacceptable quality control parameter were not included in the table.

b. The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).

c. The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

J = Questionable LCS recovery or analytical yield.

NA = Not applicable

RME = Reasonable Maximum Exposure.

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Table A-2. (OU 3-13 ROD Table 5-8) Summary sampling results statistics for radionuclides at Sites CPP-04/05.^a

Contaminants	Soil Concentration (mg/kg [nonradionuclide] or pCi/g [radionuclide])				RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean	Standard Deviation						
Ce-144	2.00E-01	2.39E+03	1.20E+02	3.28E+02	7.76E+02	204	133	65%	NA	NA
Co-60	1.05E-02	1.45E+03	4.62E+01	1.57E+02	3.60E+02	204	172	84%	NA	NA
Cs-134	7.50E-02	2.26E+02	1.81E+01	3.77E+01	9.35E+01	204	89	44%	NA	NA
Cs-137	2.19E-01	2.65E+04	9.60E+02	3.27E+03	7.50E+03	204	204	100%	8.20E-01	196
Eu-152	2.00E-01	3.50E+04	9.32E+02	3.49E+03	7.91E+03	204	199	98%	NA	NA
Eu-154	4.73E-01	3.22E+04	9.31E+02	3.34E+03	7.61E+03	204	187	92%	NA	NA
Eu-155	5.38E-03	7.60E+03	2.27E+02	7.96E+02	1.82E+03	204	178	87%	NA	NA
U-235	4.75E-02	3.02E-01	7.01E-02	3.62E-02	1.43E-01	120	120	100%	NA	NA

a. NOTE:

- Duplicate sample results were not included in the statistical analysis.
- Analytical results are from samples collected from 51 borings installed to characterize the CPP-740 horizontal settling basin in 1981. Results are provided in the Radioactive Waste Characterization of CPP-603 Cleanup Basin-CPP-740 (EG&G 1982) and in Appendix E of the Preliminary Scoping Track 2 Summary Report For Operable Unit 3-09 (LITCO 1995b).
- b. The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).
- c. The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

NA = Not applicable

RME = Reasonable Maximum Exposure.

The COPCs for CPP-04/05 include Ce-144, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, and U-235. The areal extent of contamination is estimated at 408 m^2 ($4,422 \text{ ft}^2$). Assuming an average depth of contamination of 0.6 m (2.0 ft), the total volume of contaminated soil is estimated at 245 m^3 ($8,844 \text{ ft}^3$).

CPP-08/09 (Contaminated Soil Area Around CPP-603 Basin Filter System). These sites were combined because they were determined to have resulted from failure of an underground carbon steel filter system line due to corrosion. Approximately 251 m^3 ($2,700 \text{ ft}^3$) of soil were contaminated with approximately 79,494 L (21,000 gal) of radionuclide-contaminated water from the CPP-603 basin over a 7-day period.

The exact location of the leak was never determined. The leaking line section was replaced and removed from service. Contaminated soil resulting from the leak was apparently encountered by construction crews on the east side of CPP-603, where a section of the line was located. The area of contamination was delineated by radiological survey instruments, however no soil samples were collected. Site CPP-09 was identified in the FFA/CO as "soil contamination northeast corner of CPP-603 South Basin." Site CPP-08 was identified as "CPP-603 Basin Filter System Line Failure." Sites CPP-08 and -09 were combined as one site based on information gathered during preparation of Track 2 investigation for each site. Table A-3 (ROD Table 5-9) provides summary sampling results statistics for CPP-08/09.

The COPCs include Cs-137, Sr-90, Eu-152, Eu-154 and U-235. The assumed areal extent is 251 m^2 (2700 ft^2). The assumed depth of contamination is 9.4 m (31 ft), with an estimated contaminated soil volume of $2,370 \text{ m}^3$ ($83,700 \text{ ft}^3$).

CPP-10 (Contaminated Soil Area around CPP-603 Plastic Pipeline Break). This site resulted from a release of approximately 3000 L (800 gal) of radionuclide-contaminated CPP-603 basin water that drained onto a shielded floor area as a result of failure of a PVC line in December 1976. Approximately 34 m^2 (366 ft^2) of asphalt and soil outside the building were contaminated. Apparently no remedial actions were performed at the site, other than placing several inches of clean soil over the contaminated area. Table A-4 (ROD Table 5-10) provides summary sampling results statistics for CPP-10.

Radionuclide contaminants include Co-60, Cs-137, Eu-152, -154, and -155, Sr-90, and U-235. The estimated area of CPP-10 is 31.2 m^2 (336 ft^2). Contamination is assumed to extend from ground surface to the soil-basalt interface at 10.4 m (34 ft) bgs.

CPP-11 (CPP-603 Sludge and Water Release). This site resulted from a release of contaminated sludge and water from CPP-603 in February 1978. Approximately 1,136 to 1,893 L (300 to 500 gal) of sludge and water were released, and covered an area of $8.5 \times 17 \text{ m}$ ($28 \times 56 \text{ ft}$). The initial spill was cleaned up and soils with radiation levels greater than 1 R/hr were removed.

The remainder of the area was roped off. Tank SFE-06 is located 1.8 m (6 ft) bgs at the site, and is still used for storage of radionuclide-contaminated waste. The tank is not known to be leaking. Summary sampling results statistics are provided in Table A-5 (ROD Table 5-11).

Contaminants of potential concern include arsenic, thorium, Co-60, Sr-90, Cs-137, Eu-154, and Np-237. Contamination is estimated to extend from ground surface to 5.5 m (18 ft) bgs. This estimate was based on radionuclide activities above background in samples collected at 3.8 m (12.5 ft) bgs.

Radionuclide activities were still above background levels at that depth; however, COPC activities decrease with depth. The areal extent of the site is 208 m^2 ($2,240 \text{ ft}^2$). The total estimated contaminated soil volume is $1,140 \text{ m}^3$ ($40,390 \text{ ft}^3$).

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Table A-3. (OU 3-13 ROD Table 5-9) Summary sampling results statistics for soil contaminants at Site CPP-08/09.^a

Contaminants	Soil Concentration (pCi/g [radionuclide])			RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean						
Cs-137	1.49E+01	1.08E+03	5.32E+02	5.83E+02	1.70E+03	4	4	100%	8.20E-01
Eu-152	4.38E+00	4.38E+00	4.38E+00	NA	NA	4	1	25%	NA
Eu-154	7.78E-01	2.95E+00	1.86E+00	1.54E+00	4.94E+00	4	2	50%	NA
Sr-90	2.52E+01 J	1.40E+02	8.53E+01	5.76E+01	2.01E+02	3	3	100%	4.90E-01
U-235	1.93E-02	2.61E-02	2.27E-02	4.81E-03	3.23E-02	2	2	100%	NA
U-238	1.56E-01	1.61E-01	1.59E-01	3.54E-03	1.66E-01	2	2	100%	1.40E+00
Gross Alpha	5.10E+00	7.99E+01	2.91E+01	3.48E+01	9.87E+01	4	4	100%	NA
Gross Beta	9.88E+01	9.36E+02	5.19E+02	4.34E+02	1.39E+03	4	4	100%	NA

a. NOTE:

- Duplicate sample results were not included in the statistical analysis.
- Analytical results are from samples collected from one boring installed during the OU 3-09 Track 2 Investigation. Results are provided in the Final Preliminary Scoping Track 2 Summary Report For Operable Unit OU 3-09 (LITCO 1995b) and Appendix G of the OU3-13 RI/FS Part A (DOE-ID 1997b).
- Selected samples were also analyzed for Co-57, Co-60, Eu-155, K-40, U-234, Np-237, Pu-238, Pu-239 and Am-241. This data is not shown because concentrations were below detection limits.
- Samples rejected because of an unacceptable quality control parameter were not included in the table.

- b. The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).
- c. The INEEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

J = Questionable LCS recovery or analytical yield.

NA = Not applicable

RME = Reasonable Maximum Exposure.

Table A-4. (OU 3-13 ROD Table 5-10) Summary sampling results statistics for soil contaminants at Site CPP-10.^a

Contaminants	Soil Concentration (pCi/g [radionuclide])			RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean						
Co-60	3.18E+00	3.18E+00	3.18E+00	NA	6	1	17%	NA	NA
Cs-137	2.15E+00	1.19E+03	4.91E+02	5.36E+02	1.56E+03	6	6	100%	8.20E-01
Eu-152	9.16E+00	9.16E+00	9.16E+00	NA	NA	6	1	17%	NA
Eu-154	5.70E+00	5.70E+00	NA	NA	NA	6	1	17%	NA
Eu-155	1.48E+00	1.48E+00	1.48E+00	NA	NA	6	1	17%	NA
Sr-90	4.17E+01	5.83E+01 J	5.00E+01	1.17E+01	7.34E+01	2	2	100%	4.90E-01
U-235	1.13E-02	1.42E-02	1.28E-02	1.46E-03	1.57E-02	3	3	100%	NA
U-238	1.76E-01	2.10E-01	1.88E-01	1.88E-02	2.26E-01	3	3	100%	1.4
Gross Alpha	2.78E+00	1.38E+02	4.97E+01	5.65E+01	1.63E+02	6	5	83%	NA
Gross Beta	1.42E+02	5.45E+03	1.48E+03	2.05E+03	5.58E+03	6	6	100%	NA

a. NOTE:

- Duplicate sample results were not included in the statistical analysis.
- Analytical results are from samples collected from one boring installed during the OU 3-09 Track 2 investigation. Results are provided in the Final Preliminary Scoping Track 2 Summary Report For Operable Unit OU 3-09 (LLITCO 1995b) and Appendix G of the OU3-13 RI/FS Part A (DOE-ID 1997b).
- Selected samples were also analyzed for C-57, K-40, U-234, Np-237, Pu-239 and Am-241. This data is not shown because concentrations were below detection limits.
- Samples rejected because of an unacceptable quality control parameter were not included in the table.
- The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).
- The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

J = Questionable LCS recovery or analytical yield.

NA = Not applicable

RME = Reasonable Maximum Exposure.

Table A-5. (OU 3-13 ROD Table 5-11) Summary sampling results statistics for soil contaminants at Site CPP-11.^a

Contaminants	Soil Concentration (mg/kg [nonradionuclide] or pCi/g [radionuclide])			RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean						
As	2.80E+00	6.40E+00	4.77E+00	1.27E+00	7.31E+00	10	10	100%	5.80E+00
Ba	6.34E+01 P	1.22E+02 P	9.76E+01	1.96E+01	1.37E+02	10	10	100%	3.00E+02
Be	2.50E-01 P	5E-01 P	4.23E-01	7.32E-02	5.69E-01	10	10	100%	1.80E+00
Cd	4.30E-01 P	1.70E+00 P	1.12E+00	5.00E-01	2.12E+00	10	10	100%	2.20E+00
Co	3.50E+00 B P	6.30E+00 B P	5.13E+00	7.83E-01	6.70E+00	10	10	100%	1.10E+01
Cr	1.32E+01 J P	2.37E+01 P	1.85E+01	3.07E+00	2.46E+01	10	10	100%	3.30E+01
Cu	7.80E+00 P	1.54E+01 P	1.31E+01	2.26E+00	1.76E+01	10	10	100%	2.20E+01
Hg	5.00E-02 B	5.00E-02 B	5.00E-02	NA	NA	10	1	10%	5.00E-02
Mn	1.32E+02 P	2.58E+02 NJ P	1.97E+02	4.44E+01	2.86E+02	10	10	100%	4.90E+02
Ni	1.16E+01 P	2.06E+01 P	1.73E+01	2.78E+00	2.29E+01	10	10	100%	3.50E+01
Pb	5.30E+00 P	8.80E+00 P	6.96E+00	1.11E+00	9.18E+00	10	10	100%	1.70E+01
Sb	4.40E-01 B P	8.30E-01 B P	6.06E-01	1.56E-01	9.18E-01	10	9	90%	4.80E+00
Se	8.50E-01 B P	8.50E-01 B P	8.50E-01	NA	NA	10	1	10%	2.20E-01
Th	1.30E+00 B P	1.30E+00 B	1.30E+00	NA	NA	10	1	10%	4.30E-01
V	1.83E+01	2.81E+01	2.50E+01	3.14E+00	3.13E+01	10	10	100%	4.50E+01
Zn	3.29E+01	6.42E+01	5.04E+01	8.44E+00	6.73E+01	10	10	100%	1.50E+02
Co-60	1.10E+01	6.10E-01	2.93E-01	2.75E-01	8.43E-01	10	3	30%	NA
Cs-137	2.90E-01	7.27E+01	2.56E+01	2.64E+01	7.84E+01	10	10	100%	8.20E-01
Eu-154	3.60E-01	1.80E+00	7.53E-01	5.64E-01	1.88E+00	10	6	60%	NA
Np-237	1.50E-01	1.50E-01	1.50E-01	NA	NA	1	1	100%	NA
Sr-90	1.31E+01 J	1.31E+01 J	1.31E+01	NA	NA	1	1	100%	4.90E-01
U-234	1.20E+00	1.20E+00	1.20E+00	NA	NA	1	1	100%	1.44E+00
U-238	1.00E+00	1.00E+00	1.00E+00	NA	NA	1	1	100%	1.40E+00

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Table A-5. (continued).

Contaminants	Soil Concentration (mg/kg [nonradionuclide] or pCi/g [radionuclide])				Number of Samples	Number of of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean	Standard Deviation					
Gross Alpha	4.60E+00	2.30E+01	1.11E+01	5.16E+00	2.14E+01	10	10	100%	NA
Gross Beta	2.40E+01	2.98E+03 J	3.74E+02	9.17E+02	2.21E+03	10	10	100%	NA

a. NOTE:

- Duplicate sample results were not included in the statistical analysis.
- Analytical results are from samples collected from three borings installed during the OU 3-13 RI. Results are provided in Appendix G of the OU 3-13 RI/FS Part A (DOE-ID 1997b) and the ERIS Database.
- Samples were analyzed for CLP Metals and Radiological Constituents. Only those constituents that were identified above detection limits in the samples are shown in the table except for the following constituents which were detected but are not considered to be present at hazardous concentrations: Al, Ca, Fe, Mg, K and Na.
- Samples rejected because of an unacceptable quality control parameter were not included in the table.

b. The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).

c. The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

J = (Non-Rad) The analyte was identified in the sample but the numerical result may not be accurate.

J = (Rad) The result is statistically positive at the 95% confidence level and is considered to be an estimated quantity.

B = The analyte reported value is < RDL, but > IDL.

N = Spiked sample recovery not within control limit.

P = Sample analysis by inductively coupled plasma atomic emission spectroscopy.

NA = Not applicable

RME = Reasonable Maximum Exposure.

CPP-03 (Temporary Storage Area Southeast of CPP-603). Site CPP-03 is a temporary storage area southeast of CPP-603 that was used to store old and abandoned equipment, most of which was radioactively contaminated. The area was decommissioned in the late 1970s and all stored material was boxed and sent to the RWMC for disposal. Contaminated soil was removed, boxed and sent to the RWMC, and the area was covered with 28 cm (11 in.) of "cold" soil. Subsequently, 9,175 m³ (12,000 yd³) of contaminated soil excavated from the Tank Farm was stockpiled at the site before burial in three trenches located in the northeast corner of the INTEC.

Radiological field surveys in the area have indicated surface activity levels above background at various locations at the site. Three boreholes in the area were drilled to 3.0 m (10 ft) bgs in locations where high surface activities were observed. Samples were collected and submitted for radionuclide analysis. Summary sampling results statistics are provided in Table A-6 (ROD Table 5-12). The COPCs include Cs-137 and Sr-90. Cesium-137 is the primary COC, with contamination detected from the surface to about 1.2 m (4 ft) bgs. The areal extent of contamination is estimated at 6,970 m² (75,000 ft²), and the estimated volume of contaminated soil is 8,364 m³ (300,000 ft³).

CPP-19 (CPP-603 to -604 Line Leak). This site resulted from a 1978 release of 7,570 L (2,000 gal) of radionuclide-contaminated liquid that leaked from an underground waste transfer line between CPP-603 and WL-102 in CPP-604. The waste transfer line was constructed of 304 stainless steel that reduced from a 3.81- to 3.18-cm (1-1/2- to 1-1/4-in.) diameter line and ran for 530 m (0.33 mi) at a depth of approximately 1.5 m (5 ft) bgs. The major area of contamination was estimated at the time to be approximately 10 m² (108 ft²) on the surface. The waste transfer line was abandoned in place after the leak was discovered. Table A-7 (ROD Table 5-16) shows summary sampling results statistics for soil contaminants for CPP-19.

Numerous radionuclides were identified as COPCs for Site CPP-19. Cesium-137, Sr-90, and isotopes of europium are the most widespread and are found at the highest activity levels. These COPCs range in activity as high as 408,000 pCi/g for Cs-137 at boring CPP-19-2 drilled at the site of the release.

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Table A-6. (OU 3-13 ROD Table 5-12) Summary sampling results statistics for soil contaminants at Site CPP-03.^a

Contaminants	Soil Concentration (pCi/g [radionuclide])				RME ^b	Number of Samples	Number of Detects	Frequency of Detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean	Standard Deviation						
Cs-137	2.53E-01	6.16E+01	1.89E+01	2.46E+01	6.81E+01	9	7	78%	8.20E-01	7
Sr-90	1.60E+01	4.39E+01 J	3.00E+01	1.97E+01	6.94E+01	2	2	100%	4.90E-01	3
Gross Alpha	0.00E+00	7.24E+00	3.57E+00	3.25E+00	1.01E+01	9	4	44%	NA	NA
Gross Beta	3.02E+00	1.67E+02	4.68E+01	6.76E+01	1.82E+02	9	6	67%	NA	NA

a. NOTE:

• Duplicate sample results were not included in the statistical analysis.

• Analytical results are from samples collected from three borings installed during the OU 3-09 Track 2 Investigation. Results are provided in the Final Preliminary Scoping Track 2 Summary Report For Operable Unit OU 3-09 (LITCO 1995b) and Appendix G of the OU 3-13 RI/FS Part A (DOE-ID 1997b).

• Selected samples were also analyzed for Co-57, Co-60, Eu-152, Eu-154, Eu-155 and K-40. This data is not shown because concentrations were below detection limits.

• Samples rejected because of an unacceptable quality control parameter were not included in the table.

b. The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).

c. The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).

J = Questionable LCS recovery or analytical yield.

NA = Not applicable

RME = Reasonable Maximum Exposure.

Table A-7. (OU 3-13 ROD Table 5-16) Summary sampling results statistics for soil contaminants at Site CPP-19.^a

Contaminants	Soil Concentration				Number of Samples	Number of Detects	Frequency of detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Mean	Standard Deviation					
As	3.10E+00 JP	7.00E+00 JP	4.65E+00	1.23E+00	7.11E+00	10	10	100%	5.80E+00
Ba	4.45E+01 P	1.84E+02 P	1.03E+02	4.64E+01	1.96E+02	10	10	100%	3.00E+02
Be	1.60E-01 P	6.60E-01 P	4.08E-01	1.56E-01	7.20E-01	10	10	100%	1.80E+00
Ca	2.18E+03 P	2.32E+05 P	3.53E+04	6.97E+04	1.75E+05	10	10	100%	2.40E+04
Cd	1.30E-01 BP	9.60E-01 BP	4.33E-01	2.92E-01	1.02E+00	21	10	100%	2.20E+00
Co	1.90E+00 BP	8.20E+00 BP	4.77E+00	2.00E+00	8.77E+00	10	10	100%	1.10E+01
Cr	5.10E+00 JP	2.63E+01 P	1.54E+01	7.45E+00	3.03E+01	10	10	100%	3.30E+01
Cu	6.00E+00 P	1.67E+01 P	1.25E+01	3.85E+00	2.02E+01	10	10	100%	2.20E+01
Hg	1.50E-01	1.50E-01	1.50E-01	0.00E+00	1.50E-01	10	1	10%	5.00E-02
Mn	9.11E+01 P	2.94E+02 NJP	1.80E+02	6.77E+01	3.15E+02	10	10	100%	4.90E+02
Ni	8.40E+00 P	2.64E+01 P	1.65E+01	5.76E+00	2.80E+01	10	10	100%	3.50E+01
Pb	3.80E+00 JP	1.01E+01 P	6.86E+00	1.80E+00	1.05E+01	10	10	100%	1.70E+01
Sb	5.30E-01 BP	8.30E-01 BP	7.12E-01	1.13E-01	9.38E-01	10	6	60%	4.80E+00
V	6.50E+00 BP	3.64E+01 P	1.94E+01	1.04E+01	4.02E+01	10	10	100%	4.50E+01
Zn	2.21E+01 NJP	8.60E+01 P	4.75E+01	2.00E+01	8.75E+01	10	10	100%	1.50E+02
Am-241	1.97E+00	1.97E+00	1.97E+00	NA	NA	3	1	100%	1.10E-02
Co-60	1.90E-01	2.16E+04	1.08E+04	1.53E+04	4.14E+04	21	2	10%	NA
Cs-134	5.00E-02	6.00E-02	5.50E-02	7.07E-03	6.91E-02	10	2	20%	NA
Cs-137	6.00E-02	4.08E+05	3.40E+04	1.18E+05	2.70E+05	21	12	57%	8.20E-01
Eu-152	1.52E+00	8.76E+04	2.92E+04	5.06E+04	1.30E+05	11	3	27%	NA
Eu-154	1.70E-01	5.35E+04	1.34E+04	2.67E+04	6.68E+04	21	4	19%	NA
Eu-155	1.60E-01	9.62E+03	3.21E+03	5.55E+03	1.43E+04	21	3	14%	NA
Nb-95	6.00E-02	9.00E-02	7.33E-02	1.53E-02	1.04E-01	10	3	30%	NA

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Contaminants	Soil Concentration mg/kg [nonradionuclide] or pCi/g [radionuclide])			RME ^b	Number of Samples	Number of Detects	Frequency of detection	INEEL Background ^c (mg/kg or pCi/g)	Number of Samples Greater than Background
	Minimum	Maximum	Arithmetic Mean						
Pu-239/240	1.41E+02	1.41E+02	1.41E+02	NA	1	1	100%	1.00E-01	1
Sr-90	2.85E+01	1.25E+05	2.68E+04	5.02E+04	1.27E+05	10	8	80%	4.90E-01
U-235	1.73E-02	2.36E+00	8.17E-01	1.34E+00	3.50E+00	5	3	60%	NA
U-238	1.56E-01	4.53E-01	2.58E-01	1.69E-01	5.96E-01	5	3	60%	1.40E+00
Gross Alpha	1.57E+00	1.61E+04	1.50E+03	4.50E+03	1.05E+04	21	19	100%	NA
Gross Beta	2.51E+00	5.48E+05	3.53E+04	1.25E+05	2.85E+05	21	21	90%	NA

a. NOTE:

- Duplicate sample results were not included in the statistical analysis.
- Analytical results are from samples collected from two borings installed during the OU 3-09 Track 2 Investigation and two borings installed during the OU 3-13 RI. Results are provided in the Final Preliminary Scoping Track 2 Summary Report For Operable Unit OU 3-09 (LITCO 1995b), Appendix G of the OU 3-13 RI/FS Part A (DOE-ID 1997b) and the ERIS Database.
- Samples were analyzed for CLP Metals and Radiological Constituents. Only those constituents that were identified above detection limits in the samples are shown in the table except for the following constituents which were detected but are not considered to be present at hazardous concentrations: Al, Fe, Mg, K, Na and K-40.
- Samples rejected because of an unacceptable quality control parameter are not included in the table.
- The RME concentration is the 95% upper value based on the empirical rule (95% of the measurements lie within two standard deviations of their mean).
- The INEEL background concentrations represent the 95% upper confidence limit (Rood et al. 1995).
- J = The analyte was identified in the sample but the numerical result may not be accurate.
- B = The analytic reported value is < RDI, but > IDI.

N = Spiked sample recovery not within control limits.

P = Sample analysis by inductively coupled plasma atomic emission spectroscopy.

NA = Not applicable

RME = Reasonable Maximum Exposure.

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Appendix B

GWSCREEN Model Results

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Appendix B

GWSCREEN Model Results

GWSCREEN Input Deck

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CPP-603 - radionuclides - OU3-13 Soils screening calc (I=10cm/y) - Feb. 20, 2004
2 3 1 1 1                               (Card 2) imode,itype,idisp,kflag,idil
1 1 2 1 2                               (Card 3) imodel,isolve,isolveu,imoist,imoistu
6 15 0.01                                (Card 4) jstart,jmax,eps
70. 2.555E+04 2.0 350. 30. 1.0E-6      (Card 5) bw,at,wi,ef,ed,dlim
0. 0.                                     (Card 6) x0,y0
100. 100. 0.10                           (Card 7) l,w,perc
9.5 1.5                                    (Card 8b) thick,s,rhos,(source term values)
0.30                                       (Card 8c) thetas,(source term mc)
22.7 1.359 2.92                         (Card 9) depth,rhou,axu

$ NOTE: The values of depth and axu are the ucode calibrated values
$ van Genuchten parameters from EDF-ER-275 60% Design Component Report Table 2-2 and 2-3
1.066 1.523 21.13 0.487 0.142          (Card 9b) alphau nu ksatu porsu thetaru
$use calib values for ax and az ay=0.2ax and az=1.16e-3ax as stated in the MEPAS Manual
$but ax, ay, and az are ignored if idisp > 0.
3.31 0.2 1.163E-3 76. 15.              (Card 10) ax,ay,az,b,z(well screen thickness)
$ Aqui dens and porosity from EDF-ER-275 60% Design Component Report Table 2-2 and 2-3
$ --- Darcy velocity based on an assumed pore vel of ~ 1 m/d in EDF-ER-275
21.9 0.06 2.491                         (Card 11) u,phi,rhoa
1                                         (Card 12a) nrecept
150. 0.                                     (Card 12b) x y
13                                         (Card 14) ncontam

$ ----- Am-241 (Np) ----- 1
3 340. 340. 237 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'Am-241' 432. 13.6 3.28E+02            (card14b) cname thalf kda dcf
'Np-237' 2.140E+06 0.32 3.00E+02       (card14b) cname thalf kda dcf
'U-233' 1.592E+05 0.24 4.48E+01        (card14b) cname thalf kda dcf
'Th-229' 7.340E+03 4 3.56E+02          (card14b) cname thalf kda dcf
$ ----- C-14 ----- 2
0 0.1 0.1 14 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'C-14' 5.730E+03 0.004 1.03E+00        (card14b) cname thalf kda dcf
$ ----- H-3 ----- 3
0 0. 0. 3 1. 0. 0. 1.0E+06 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'H-3' 12.3 0. 7.2E-02                  (card14b) cname thalf kda dcf
$ ----- I-129 ----- 3
0 0.1 0.1 129 1. 0. 1.0E+06 0.         (card14a) nprog kds kdu zmw qi rmi sl other
'I-129' 1.57E+07 0.004 1.84E+02        (card14b) cname thalf kda dcf
$ ----- Np-237 ----- 5
2 8. 8. 237 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'Np-237' 2.14E+06 0.32 3.00E+02       (card14b) cname thalf kda dcf
'U-233' 1.59B+05 0.24 4.48E+01        (card14b) cname thalf kda dcf
'Th-229' 7.34E+03 4. 3.56E+02          (card14b) cname thalf kda dcf
$ ----- Pu-238 ----- 6
4 140. 140. 238. 1. 0. 1.0E6 0.0       (Card 12a) nprog kds kdu zmw q0 rmi sl other
Pu-238 87.8 5.6 2.95E+02             (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
U-234 2.45E5 0.24 4.44E+01           (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
Th-230 7.54E4 4.0 3.75E+01           (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
Ra-226 1.60E3 4.0 2.96E+02           (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
Pb-210 22.3 4.0 1.01E+03             (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
$ ----- Pu-239 ----- 5
3 140. 140. 239 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-239' 2.410E+04 5.6 3.16E+02       (card14b) cname thalf kda dcf
'U-235' 7.037E+08 0.24 4.70E+01       (card14b) cname thalf kda dcf
'Pa-231' 3.276E+04 22 1.49E+02         (card14b) cname thalf kda dcf
'Ac-227' 2.177E+01 18 6.26E+02         (card14b) cname thalf kda dcf
$ ----- Pu-240 ----- 6
4 140. 140. 240 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'Pu-240' 6.560E+03 5.6 3.15E+02       (card14b) cname thalf kda dcf
'U-236' 2.342E+07 0.24 4.21E+01       (card14b) cname thalf kda dcf
'Th-232' 1.410E+10 4 3.28E+01          (card14b) cname thalf kda dcf
'Ra-228' 5.750E+00 4 2.48E+02          (card14b) cname thalf kda dcf
'Th-228' 1.910E+00 4 2.31E+02          (card14b) cname thalf kda dcf
$ ----- Tc-99 ----- 7
0 0.2 0.2 99 1. 0. 1.E+6 0.          (card14a) nprog kds kdu zmw qi rmi sl other
'Tc-99' 2.111E+05 0.008 1.40E+00        (card14b) cname thalf kda dcf
```

```
$ ----- U-234 ----- 8
3 6. 234 1. 0. 1.E+6 0. (card14a) nprog kds kdu zmw qi rmi sl other
'U-234' 2.45E+05 0.24 4.44E+01 (card14b) cname thalf kda dcf
'Th-230' 7.54E+04 4 3.75E+01 (card14b) cname thalf kda dcf
'Ra-226' 1.60E+03 4 2.96E+02 (card14b) cname thalf kda dcf
'Pb-210' 2.23E+01 4 1.01E+03 (card14b) cname thalf kda dcf
$ ----- U-235 ----- 9
2 6. 6. 235. 1. 0. 1.0E6 0.0 (Card 12a) nprog kds kdu zmw q0 rmi sl other
U-235 7.04E8 0.24 4.70E+01 (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
Pa-231 3.28E4 22.0 1.49E+02 (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
Ac-227 21.8 18.0 6.26E+02 (Card 12b) cname(i),thalf(i),kda(i),dcf(i)
$ ----- U-236 ----- 9
3 6. 6. 236 1. 0. 1.E+6 0. (card14a) nprog kds kdu zmw qi rmi sl other
'U-236' 2.342E+07 0.24 4.21E+01 (card14b) cname thalf kda dcf
'Th-232' 1.410E+10 4 3.28E+01 (card14b) cname thalf kda dcf
'Ra-228' 5.750E+00 4 2.48E+02 (card14b) cname thalf kda dcf
'Th-228' 1.910E+00 4 2.31E+02 (card14b) cname thalf kda dcf
$ ----- U-238 ----- 9
4 6. 6. 238 1. 0. 1.E+6 0. (card14a) nprog kds kdu zmw qi rmi sl other
'U-238' 4.47E+09 0.24 6.20E+01 (card14b) cname thalf kda dcf
'U-234' 2.45E+05 0.24 4.44E+01 (card14b) cname thalf kda dcf
'Th-230' 7.54E+04 4 3.75E+01 (card14b) cname thalf kda dcf
'Ra-226' 1.60E+03 4 2.96E+02 (card14b) cname thalf kda dcf
'Pb-210' 2.23E+01 4 1.01E+03 (card14b) cname thalf kda dcf
```

GWSCREEN Output

```
*****
* This output was produced by the model: *
*
*          GWSCREEN *
*          Version 2.5a *
* A semi-analytical model for the assessment *
* of the groundwater pathway from the leaching *
* of surficial and buried contamination and *
* release of contaminants from percolation ponds *
*          08/26/2003 *
*          Arthur S. Rood *
*          Idaho National Engineering and *
*          Environmental Laboratory *
*          PO Box 1625 *
*          Idaho Falls, Idaho 83415 *
*****
```

ACKNOWLEDGEMENT OF GOVERNMENT SPONSORSHIP AND LIMITATION OF LIABILITY

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```
=====
OUTPUT FILE NAME: 3-13-soils-rad.out
INPUT FILE NAME: 3-13-soils-rad.par
Title: CPP-603 - radionuclides - OU3-13 Soils screening calc (I=10cm/y) - Feb. 20, 2004
```

Model Run Options

```
IMODE Contaminant Type and Impacts:          2
ITYPE (1) Vert Avg (2) 3D Point (3) 3d Avg:   3
IDISP (0) Fixed Dispersivity (1-3) Spatially Varying: 1
KFLAG (1) Max Conc (2) Conc vs Time (3) Grid Output: 1
IDIL (1) No dilution factor (2) Include Dilution Factor: 1
IMOIST Source Moisture Content Option:        1
IMOISTU Unsaturated Moisture Content Option:  2
IMODEL (1) Surface/Burried Src (2) Pond (3) Usr Def: 1
ISOLVE (1) Gaussian Quarature (2) Simpsons Rule: (Aquifer) 1
ISOLVEU (1) Gaussian Quarature (2) Simpsons Rule: (Unsat Zone) 2
```

```
JSTART: 6
JMAX : 15
EPS  : 1.000E-02
```

Health Effects: Carcinogenic incidence risk for radionuclides
Output mass/activity units: Ci
Output concentration units: Ci/m**3
Dose/Risk Conversion Units: 1/Ci
Output health effects units: carcinogenic risk

Exposure Parameters

```
Body Mass (kg):      70.      Averaging Time (days): 25550.
Water Ingestion (L/d): 2.000E+00 Exposure Freq (day/year): 3.500E+02
Exposure Duration (y): 3.000E+01 Limiting Dose: 1.000E-06
```

Site Parameters

```
X Coordinate:      0.000E+00 Y Coordinate:      0.000E+00
Source Length (m): 1.000E+02 Source Width (m): 1.000E+02
Percolation Rate (m/y): 1.000E-01
Source Thickness (m): 9.500E+00 Src Bulk Density (g/cc): 1.500E+00
Source Moisture Content: 3.000E-01
```

Unsaturated Zone Parameters

Unsat Zone Thickness (m): 2.270E+01 Unsat Bulk Density: 1.359E+00
Unsat Alpha (1/m): 1.066E+00 Unsat n: 1.523E+00
Saturated K in Unsat (m/y): 2.113E+01 Porosity of Unsat Zone: 4.870E-01
Unsat Residual Moisture: 1.420E-01 Unsat Dispersion (m): 2.920E+00

Aquifer Zone Parameters

Transverse/Longitudinal Ratio: 2.000E-01 Vertical/Longitudinal Ratio: 1.163E-03
Aquifer Thickness (m): 7.600E+01 Well Screen Thickness (m): 1.500E+01
Darcy Velocity (m/y): 2.190E+01 Aquifer Porosity: 6.000E-02
Bulk Density (g/cc): 2.491E+00

Calculated Flow Parameters

Percolation Water Flux (m³/y): 1.0000E+03
Unsaturated Moisture Content: 3.4455E-01
Unsat Pore Velocity (m/y): 2.9023E-01
Aquifer Pore Velocity (m/y): 3.6500E+02

Contaminant Data

Contaminant Name: Am-241 (Not used)
Number of Progeny: 3
Progeny Names: Np-237 U-233 Th-229
Half Life (y): 4.320E+02 2.140E+06 1.592E+05 7.340E+03
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 3.400E+02
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 2.370E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 3.400E+02
Kd Aquifer (ml/g): 1.360E+01 3.200E-01 2.400E-01 4.000E+00
Risk/Dose Conversion Factor: 3.280E+02 3.000E+02 4.480E+01 3.560E+02

Calculated Contaminant Values

Decay Constants (1/y): 1.6045E-03 3.2390E-07 4.3539E-06 9.4434E-05
Leach Rate Constant (1/y): 2.0628E-05
Initial Pore Water Conc (Ci or mg/m**3): 2.0628E-08
Solubility Limited Mass (mg): 4.8478E+16
Solubility Limited Act (Ci): 1.6941E+14
Unsaturated Retardation Factor: 1.3420E+03
Mean Unsaturated Transit Time (y): 1.1058E+04
Leading Edge Arrival Time (y): 7.2204E+03
Aquifer Retardation Factor: 5.656E+02 1.429E+01 1.096E+01 1.671E+02
Minimum Peak Window Time (y): 7.2497E+03
Maximum Peak Window Time (y): 3.4744E+05

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y): 4.3684E+03 Y Dispersion Coeff (m²/y): 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 2.085E-25 2.113E-19 1.291E-20 3.231E-22
Time of Peak (y): 1.1631E+04
Concentrations Averaged Between: 1.1616E+04 and 1.1646E+04 years
Average Concentration (Ci/m**3): 2.085E-25 2.113E-19 1.291E-20 3.232E-22
Maximum Dose: 1.436E-21 1.331E-15 1.214E-17 2.416E-18
Total Dose (all members): 1.346E-15
Maximum Allowable Inventory (Ci): 7.430E+08

Contaminant Data

Contaminant Name: C-14
Number of Progeny: 0
Half Life (y): 5.730E+03
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 1.000E-01
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 1.400E+01
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 1.000E-01
Kd Aquifer (ml/g): 4.000E-03
Risk/Dose Conversion Factor: 1.030E+00

Calculated Contaminant Values

Decay Constants (1/y) : 1.2097E-04
Leach Rate Constant (1/y) : 2.3392E-02
Initial Pore Water Conc (Ci or mg/m**3) : 2.3392E-05
Solubility Limited Mass (mg) : 4.2750E+13
Solubility Limited Act (Ci) : 1.9067E+11
Unsaturated Retardation Factor: 1.3944E+00
Mean Unsaturated Transit Time (y) : 9.5649E+01
Leading Edge Arrival Time (y) : 7.5022E+00
Aquifer Retardation Factor: 1.166E+00
Minimum Peak Window Time (y) : 7.5652E+00
Maximum Peak Window Time (y) : 3.9273E+02

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y) : 4.3684E+03 Y Dispersion Coeff (m2/y) : 8.7368E+02
Peak Concentration (Ci/m**3) : 1.705E-07
Time of Peak (y) : 1.2341E+02
Concentrations Averaged Between: 1.0841E+02 and 1.3841E+02 years
Average Concentration (Ci/m**3) : 1.688E-07
Maximum Dose: 3.651E-06
Maximum Allowable Inventory (Ci) : 2.739E-01

Contaminant Data

Contaminant Name: H-3
Number of Progeny: 0
Half Life (y) : 1.230E+01
Other Source Loss Rate (1/y) : 0.000E+00
Kd Source (ml/g) : 0.000E+00
Solubility Limit (mg/L) : 1.000E+06
Molecular Weight (mg/L) : 3.000E+00
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g) : 0.000E+00
Kd Aquifer (ml/g) : 0.000E+00
Risk/Dose Conversion Factor: 7.200E-02

Calculated Contaminant Values

Decay Constants (1/y) : 5.6353E-02
Leach Rate Constant (1/y) : 3.5088E-02
Initial Pore Water Conc (Ci or mg/m**3) : 3.5088E-05
Solubility Limited Mass (mg) : 2.8500E+13
Solubility Limited Act (Ci) : 2.7634E+14
Unsaturated Retardation Factor: 1.0000E+00
Mean Unsaturated Transit Time (y) : 4.0297E+01
Leading Edge Arrival Time (y) : 5.3801E+00
Aquifer Retardation Factor: 1.000E+00
Minimum Peak Window Time (y) : 5.4340E+00
Maximum Peak Window Time (y) : 2.3849E+02

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y) : 4.3684E+03 Y Dispersion Coeff (m2/y) : 8.7368E+02
Peak Concentration (Ci/m**3) : 7.677E-09
Time of Peak (y) : 4.7247E+01
Concentrations Averaged Between: 3.2247E+01 and 6.2247E+01 years
Average Concentration (Ci/m**3) : 6.791E-09
Maximum Dose: 1.027E-08
Maximum Allowable Inventory (Ci) : 9.740E+01

Contaminant Data

Contaminant Name: I-129
Number of Progeny: 0
Half Life (y) : 1.570E+07
Other Source Loss Rate (1/y) : 0.000E+00
Kd Source (ml/g) : 1.000E-01
Solubility Limit (mg/L) : 1.000E+06
Molecular Weight (mg/L) : 1.290E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g) : 1.000E-01
Kd Aquifer (ml/g) : 4.000E-03
Risk/Dose Conversion Factor: 1.840E+02

Calculated Contaminant Values

Decay Constants (1/y) : 4.4150E-08
Leach Rate Constant (1/y) : 2.3392E-02
Initial Pore Water Conc (Ci or mg/m**3) : 2.3392E-05
Solubility Limited Mass (mg) : 4.2750E+13
Solubility Limited Act (Ci) : 7.5523E+06
Unsaturated Retardation Factor: 1.3944E+00
Mean Unsaturated Transit Time (y) : 9.5932E+01
Leading Edge Arrival Time (y) : 7.5022E+00
Aquifer Retardation Factor: 1.166E+00
Minimum Peak Window Time (y) : 7.5652E+00
Maximum Peak Window Time (y) : 3.9301E+02

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y) : 4.3684E+03 Y Dispersion Coeff (m2/y) : 8.7368E+02
Peak Concentration (Ci/m**3) : 1.731E-07
Time of Peak (y) : 1.2385E+02
Concentrations Averaged Between: 1.0885E+02 and 1.3885E+02 years
Average Concentration (Ci/m**3) : 1.713E-07
Maximum Dose: 6.620E-04
Maximum Allowable Inventory (Ci) : 1.511E-03

Contaminant Data

Contaminant Name: Np-237
Number of Progeny: 2
Progeny Names: U-233 Th-229
Half Life (y) : 2.140E+06 1.590E+05 7.340E+03
Other Source Loss Rate (1/y) : 0.000E+00
Kd Source (ml/g) : 8.000E+00
Solubility Limit (mg/L) : 1.000E+06
Molecular Weight (mg/L) : 2.370E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g) : 8.000E+00
Kd Aquifer (ml/g) : 3.200E-01 2.400E-01 4.000E+00
Risk/Dose Conversion Factor: 3.000E+02 4.480E+01 3.560E+02

Calculated Contaminant Values

Decay Constants (1/y) : 3.2390E-07 4.3594E-06 9.4434E-05
Leach Rate Constant (1/y) : 8.5580E-04
Initial Pore Water Conc (Ci or mg/m**3) : 8.5580E-07
Solubility Limited Mass (mg) : 1.1685E+15
Solubility Limited Act (Ci) : 8.2432E+08
Unsaturated Retardation Factor: 3.2554E+01
Mean Unsaturated Transit Time (y) : 2.2392E+03
Leading Edge Arrival Time (y) : 1.7515E+02
Aquifer Retardation Factor: 1.429E+01 1.096E+01 1.671E+02
Minimum Peak Window Time (y) : 1.7592E+02
Maximum Peak Window Time (y) : 1.0348E+04

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y) : 4.3684E+03 Y Dispersion Coeff (m2/y) : 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3) : 7.020E-09 1.185E-10 1.003E-12
Time of Peak (y) : 2.9889E+03
Concentrations Averaged Between: 2.9739E+03 and 3.0039E+03 years
Average Concentration (Ci/m**3) : 7.020E-09 1.185E-10 1.003E-12
Maximum Dose: 4.422E-05 1.114E-07 7.499E-09
Total Dose (all members) : 4.434E-05
Maximum Allowable Inventory (Ci) : 2.255E-02

Contaminant Data

Contaminant Name: Pu-238 (Not used)
Number of Progeny: 4
Progeny Names: U-234 Th-230 Ra-226 Pb-210
Half Life (y) : 8.780E+01 2.450E+05 7.540E+04 1.600E+03 2.230E+01
Other Source Loss Rate (1/y) : 0.000E+00
Kd Source (ml/g) : 1.400E+02
Solubility Limit (mg/L) : 1.000E+06
Molecular Weight (mg/L) : 2.380E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g) : 1.400E+02

Kd Aquifer (ml/g): 5.600E+00 2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor: 2.950E+02 4.440E+01 3.750E+01 2.960E+02 1.010E+03

Calculated Contaminant Values

Decay Constants (1/y): 7.8946E-03 2.8292E-06 9.1929E-06 4.3322E-04 3.1083E-02
Leach Rate Constant (1/y): 5.0054E-05
Initial Pore Water Conc (Ci or mg/m**3): 5.0054E-08
Solubility Limited Mass (mg): 1.9978E+16
Solubility Limited Act (Ci): 3.4208E+14
Unsaturated Retardation Factor: 5.5320E+02
Mean Unsaturated Transit Time (y): 3.2231E+03
Leading Edge Arrival Time (y): 2.9763E+03
Aquifer Retardation Factor: 2.335E+02 1.096E+01 1.671E+02 1.671E+02 1.671E+02
Minimum Peak Window Time (y): 2.9879E+03
Maximum Peak Window Time (y): 1.4184E+05

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y): 4.3684E+03 Y Dispersion Coeff (m²/y): 8.7368E+02

NOTE: Concentrations and Doses Reported in Order of the Decay Chain

NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 6.467E-32 1.955E-22 3.802E-25 1.775E-25 1.747E-25
Time of Peak (y): 3.3838E+03
Concentrations Averaged Between: 3.3688E+03 and 3.3988E+03 years
Average Concentration (Ci/m**3): 6.466E-32 1.959E-22 3.811E-25 1.779E-25 1.751E-25
Maximum Dose: 4.006E-28 1.827E-19 3.001E-22 1.106E-21 3.714E-21
Total Dose (all members): 1.878E-19
Maximum Allowable Inventory (Ci): 5.325E+12

Contaminant Data

Contaminant Name: Pu-239
Number of Progeny: 3
Progeny Names: U-235 Pa-231 Ac-227
Half Life (y): 2.410E+04 7.037E+08 3.276E+04 2.177E+01
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 1.400E+02
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 2.390E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 1.400E+02
Kd Aquifer (ml/g): 5.600E+00 2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor: 3.160E+02 4.700E+01 1.490E+02 6.260E+02

Calculated Contaminant Values

Decay Constants (1/y): 2.8761E-05 9.8500E-10 2.1158E-05 3.1840E-02
Leach Rate Constant (1/y): 5.0054E-05
Initial Pore Water Conc (Ci or mg/m**3): 5.0054E-08
Solubility Limited Mass (mg): 1.9978E+16
Solubility Limited Act (Ci): 1.2410E+12
Unsaturated Retardation Factor: 5.5320E+02
Mean Unsaturated Transit Time (y): 3.0560E+04
Leading Edge Arrival Time (y): 2.9763E+03
Aquifer Retardation Factor: 2.335E+02 1.096E+01 9.144E+02 7.483E+02
Minimum Peak Window Time (y): 2.9889E+03
Maximum Peak Window Time (y): 1.6919E+05

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y): 4.3684E+03 Y Dispersion Coeff (m²/y): 8.7368E+02

NOTE: Concentrations and Doses Reported in Order of the Decay Chain

NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 1.168E-10 1.727E-13 7.563E-16 9.231E-16
Time of Peak (y): 3.8518E+04
Concentrations Averaged Between: 3.8503E+04 and 3.8533E+04 years
Average Concentration (Ci/m**3): 1.168E-10 1.727E-13 7.563E-16 9.231E-16
Maximum Dose: 7.748E-07 1.704E-10 2.367E-12 1.214E-11
Total Dose (all members): 7.750E-07
Maximum Allowable Inventory (Ci): 1.290E+00

Contaminant Data

Contaminant Name: Pu-240
Number of Progeny: 4
Progeny Names: U-236 Th-232 Ra-228 Th-228
Half Life (y): 6.560E+03 2.342E+07 1.410E+10 5.750E+00 1.910E+00
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 1.400E+02

Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 2.400E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 1.400E+02
Kd Aquifer (ml/g): 5.600E+00 2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor: 3.150E+02 4.210E+01 3.280E+01 2.480E+02 2.310E+02

Calculated Contaminant Values

Decay Constants (1/y): 1.0566E-04 2.9596E-08 4.9159E-11 1.2055E-01 3.6290E-01
Leach Rate Constant (1/y): 5.0054E-05
Initial Pore Water Conc (Ci or mg/m**3): 5.0054E-08
Solubility Limited Mass (mg): 1.9978E+16
Solubility Limited Act (Ci): 4.5402E+12
Unsaturated Retardation Factor: 5.5320E+02
Mean Unsaturated Transit Time (y): 2.2029E+04
Leading Edge Arrival Time (y): 2.9763E+03
Aquifer Retardation Factor: 2.335E+02 1.096E+01 1.671E+02 1.671E+02 1.671E+02
Minimum Peak Window Time (y): 2.9889E+03
Maximum Peak Window Time (y): 1.6066E+05

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y): 4.3684E+03 Y Dispersion Coeff (m2/y): 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 1.070E-11 9.291E-13 5.486E-20 5.483E-20 5.482E-20
Time of Peak (y): 2.5977E+04
Concentrations Averaged Between: 2.5962E+04 and 2.5992E+04 years
Average Concentration (Ci/m**3): 1.070E-11 9.291E-13 5.486E-20 5.483E-20 5.482E-20
Maximum Dose: 7.079E-08 8.214E-10 3.779E-17 2.856E-16 2.660E-16
Total Dose (all members): 7.161E-08
Maximum Allowable Inventory (Ci): 1.396E+01

Contaminant Data

Contaminant Name: Tc-99
Number of Progeny: 0
Half Life (y): 2.111E+05
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 2.000E-01
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 9.900E+01
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 2.000E-01
Kd Aquifer (ml/g): 8.000E-03
Risk/Dose Conversion Factor: 1.400E+00

Calculated Contaminant Values

Decay Constants (1/y): 3.2835E-06
Leach Rate Constant (1/y): 1.7544E-02
Initial Pore Water Conc (Ci or mg/m**3): 1.7544E-05
Solubility Limited Mass (mg): 5.7000E+13
Solubility Limited Act (Ci): 9.7585E+08
Unsaturated Retardation Factor: 1.7889E+00
Mean Unsaturated Transit Time (y): 1.2305E+02
Leading Edge Arrival Time (y): 9.6243E+00
Aquifer Retardation Factor: 1.332E+00
Minimum Peak Window Time (y): 9.6963E+00
Maximum Peak Window Time (y): 5.1902E+02

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y): 4.3684E+03 Y Dispersion Coeff (m2/y): 8.7368E+02
Peak Concentration (Ci/m**3): 1.332E-07
Time of Peak (y): 1.6016E+02
Concentrations Averaged Between: 1.4516E+02 and 1.7516E+02 years
Average Concentration (Ci/m**3): 1.324E-07
Maximum Dose: 3.892E-06
Maximum Allowable Inventory (Ci): 2.570E-01

Contaminant Data

Contaminant Name:	U-234
Number of Progeny:	3
Progeny Names:	Th-230 Ra-226 Pb-210
Half Life (y):	2.450E+05 7.540E+04 1.600E+03 2.230E+01
Other Source Loss Rate (1/y):	0.000E+00
Kd Source (ml/g):	6.000E+00
Solubility Limit (mg/L):	1.000E+06
Molecular Weight (mg/L):	2.340E+02
Initial mass/activity:	1.000E+00
Kd Unsat (ml/g):	6.000E+00
Kd Aquifer (ml/g):	2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor:	4.440E+01 3.750E+01 2.960E+02 1.010E+03

Calculated Contaminant Values

Decay Constants (1/y):	2.8292E-06 9.1929E-06 4.3322E-04 3.1083E-02
Leach Rate Constant (1/y):	1.1319E-03
Initial Pore Water Conc (Ci or mg/m**3):	1.1319E-06
Solubility Limited Mass (mg):	8.8350E+14
Solubility Limited Act (Ci):	5.5138E+09
Unsaturated Retardation Factor:	2.4666E+01
Mean Unsaturated Transit Time (y):	1.6948E+03
Leading Edge Arrival Time (y):	1.3270E+02
Aquifer Retardation Factor:	1.096E+01 1.671E+02 1.671E+02 1.671E+02
Minimum Peak Window Time (y):	1.3330E+02
Maximum Peak Window Time (y):	7.8259E+03

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y): 4.3684E+03 Y Dispersion Coeff (m²/y): 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 9.222E-09 1.249E-11 4.542E-12 4.433E-12
Time of Peak (y): 2.2606E+03
Concentrations Averaged Between: 2.2456E+03 and 2.2756E+03 years
Average Concentration (Ci/m**3): 9.221E-09 1.249E-11 4.542E-12 4.433E-12
Maximum Dose: 8.598E-06 9.833E-09 2.824E-08 9.401E-08
Total Dose (all members): 8.730E-06
Maximum Allowable Inventory (Ci): 1.145E-01

Contaminant Data

Contaminant Name:	U-235
Number of Progeny:	2
Progeny Names:	Pa-231 Ac-227
Half Life (y):	7.040E+08 3.280E+04 2.180E+01
Other Source Loss Rate (1/y):	0.000E+00
Kd Source (ml/g):	6.000E+00
Solubility Limit (mg/L):	1.000E+06
Molecular Weight (mg/L):	2.350E+02
Initial mass/activity:	1.000E+00
Kd Unsat (ml/g):	6.000E+00
Kd Aquifer (ml/g):	2.400E-01 2.200E+01 1.800E+01
Risk/Dose Conversion Factor:	4.700E+01 1.490E+02 6.260E+02

Calculated Contaminant Values

Decay Constants (1/y):	9.8458E-10 2.1133E-05 3.1796E-02
Leach Rate Constant (1/y):	1.1319E-03
Initial Pore Water Conc (Ci or mg/m**3):	1.1319E-06
Solubility Limited Mass (mg):	8.8350E+14
Solubility Limited Act (Ci):	1.9107E+06
Unsaturated Retardation Factor:	2.4666E+01
Mean Unsaturated Transit Time (y):	1.6969E+03
Leading Edge Arrival Time (y):	1.3270E+02
Aquifer Retardation Factor:	1.096E+01 9.144E+02 7.483E+02
Minimum Peak Window Time (y):	1.3330E+02
Maximum Peak Window Time (y):	7.8280E+03

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y): 4.3684E+03 Y Dispersion Coeff (m²/y): 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 9.281E-09 5.199E-12 6.267E-12
Time of Peak (y): 2.2642E+03
Concentrations Averaged Between: 2.2492E+03 and 2.2792E+03 years

Average Concentration (Ci/m**3) : 9.281E-09 5.199E-12 6.267E-12
Maximum Dose: 9.160E-06 1.627E-08 8.238E-08
Total Dose (all members) : 9.259E-06
Maximum Allowable Inventory (Ci) : 1.080E-01

Contaminant Data

Contaminant Name: U-236
Number of Progeny: 3
Progeny Names: Th-232 Ra-228 Th-228
Half Life (y): 2.342E+07 1.410E+10 5.750E+00 1.910E+00
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 6.000E+00
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 2.360E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 6.000E+00
Kd Aquifer (ml/g): 2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor: 4.210E+01 3.280E+01 2.480E+02 2.310E+02

Calculated Contaminant Values

Decay Constants (1/y): 2.99596E-08 4.9159E-11 1.2055E-01 3.6290E-01
Leach Rate Constant (1/y): 1.1319E-03
Initial Pore Water Conc (Ci or mg/m**3): 1.1319E-06
Solubility Limited Mass (mg): 8.8350E+14
Solubility Limited Act (Ci): 5.7192E+07
Unsaturated Retardation Factor: 2.4666E+01
Mean Unsaturated Transit Time (y): 1.6969E+03
Leading Edge Arrival Time (y): 1.3270E+02
Aquifer Retardation Factor: 1.096E+01 1.671E+02 1.671E+02 1.671E+02
Minimum Peak Window Time (y): 1.3330E+02
Maximum Peak Window Time (y): 7.8280E+03

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m2/y): 4.3684E+03 Y Dispersion Coeff (m2/y): 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m**3): 9.280E-09 6.779E-17 6.754E-17 6.746E-17
Time of Peak (y): 2.2641E+03
Concentrations Averaged Between: 2.2491E+03 and 2.2791E+03 years
Average Concentration (Ci/m**3): 9.280E-09 6.779E-17 6.754E-17 6.746E-17
Maximum Dose: 8.204E-06 4.669E-14 3.517E-13 3.272E-13
Total Dose (all members): 8.204E-06
Maximum Allowable Inventory (Ci): 1.219E-01

Contaminant Data

Contaminant Name: U-238
Number of Progeny: 4
Progeny Names: U-234 Th-230 Ra-226 Pb-210
Half Life (y): 4.470E+09 2.450E+05 7.540E+04 1.600E+03 2.230E+01
Other Source Loss Rate (1/y): 0.000E+00
Kd Source (ml/g): 6.000E+00
Solubility Limit (mg/L): 1.000E+06
Molecular Weight (mg/L): 2.380E+02
Initial mass/activity: 1.000E+00
Kd Unsat (ml/g): 6.000E+00
Kd Aquifer (ml/g): 2.400E-01 2.400E-01 4.000E+00 4.000E+00 4.000E+00
Risk/Dose Conversion Factor: 6.200E+01 4.440E+01 3.750E+01 2.960E+02 1.010E+03

Calculated Contaminant Values

Decay Constants (1/y): 1.5507E-10 2.8292E-06 9.1929E-06 4.3322E-04 3.1083E-02
Leach Rate Constant (1/y): 1.1319E-03
Initial Pore Water Conc (Ci or mg/m**3): 1.1319E-06
Solubility Limited Mass (mg): 8.8350E+14
Solubility Limited Act (Ci): 2.9713E+05
Unsaturated Retardation Factor: 2.4666E+01
Mean Unsaturated Transit Time (y): 1.6969E+03
Leading Edge Arrival Time (y): 1.3270E+02
Aquifer Retardation Factor: 1.096E+01 1.096E+01 1.671E+02 1.671E+02 1.671E+02
Minimum Peak Window Time (y): 1.3330E+02
Maximum Peak Window Time (y): 7.8280E+03

Results for Receptor X = 1.50000E+02 Y = 0.00000E+00

X Dispersion Coeff (m²/y) : 4.3684E+03 Y Dispersion Coeff (m²/y) : 8.7368E+02
NOTE: Concentrations and Doses Reported in Order of the Decay Chain
NOTE: Progeny Concentrations are Reported at the Time of the Maximum Parent Concentration
Peak Concentration (Ci/m³*3) : 9.281E-09 5.926E-11 4.024E-14 1.049E-14 1.009E-14
Time of Peak (y) : 2.2642E+03
Concentrations Averaged Between: 2.2492E+03 and 2.2792E+03 years
Average Concentration (Ci/m³*3) : 9.281E-09 5.926E-11 4.024E-14 1.049E-14 1.009E-14
Maximum Dose: 1.208E-05 5.525E-08 3.169E-11 6.523E-11 2.140E-10
Total Dose (all members) : 1.214E-05
Maximum Allowable Inventory (Ci) : 8.238E-02
Execution Time (Seconds) : 1